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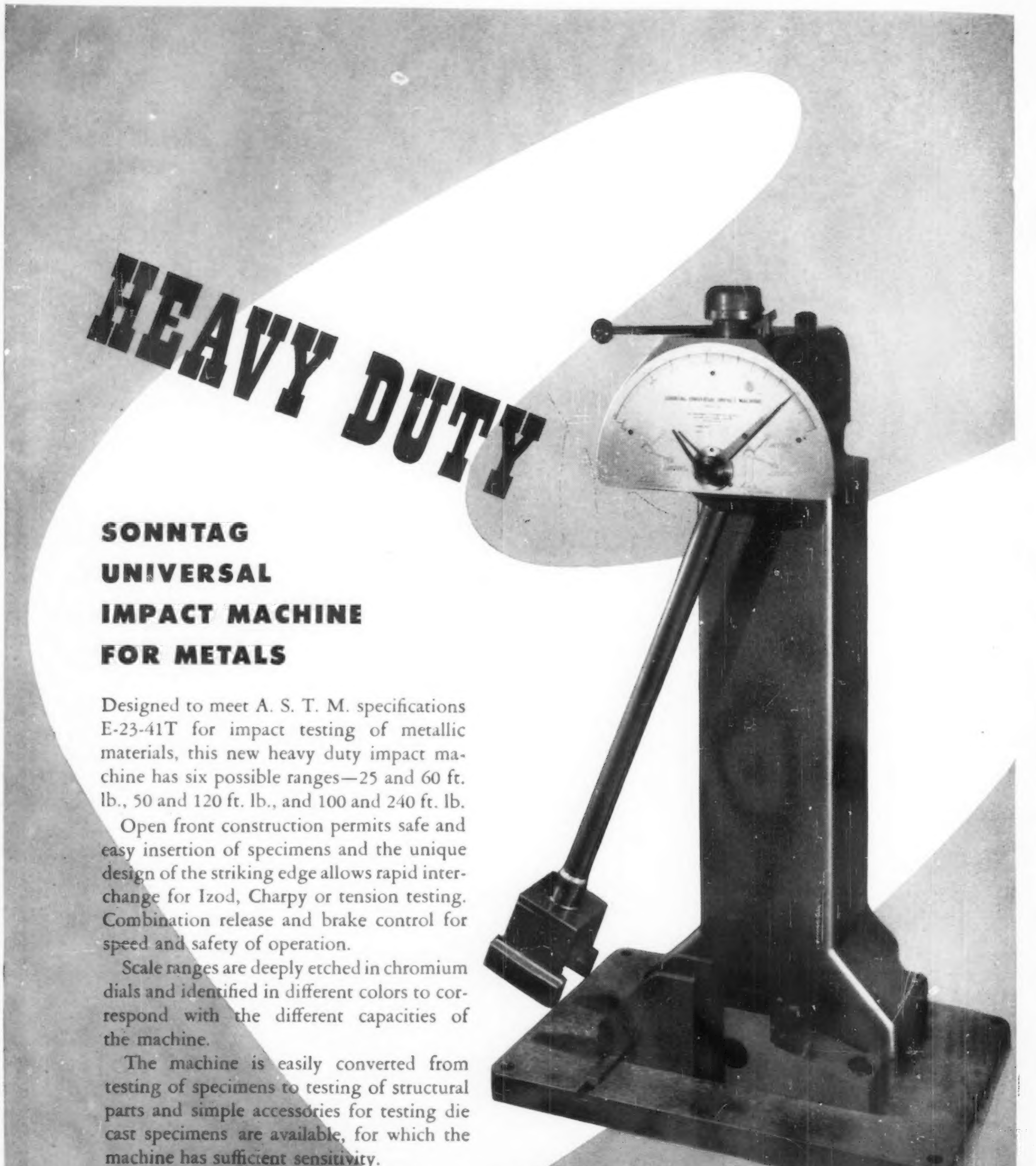
American Society for Testing Materials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ASTM BULLETIN

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AMERICAN SOCIETY for
TESTING MATERIALS

This Issue Contains

NEWS ABOUT THE SOCIETY AND ITS COMMITTEES:

MISCELLANEOUS TECHNICAL NOTES AND NEWS:

DECEMBER—1946
No. 143

Reg. U. S. Pat. Off.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

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ASTM BULLETIN

"*Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing*"

TELEPHONE—Rittenhouse 6-5315 | R. E. Hess, Editor | CABLE ADDRESS—TESTING

R. J. Painter, Associate Editor

Number 143 | December 1946

1947 Committee Week and Spring Meeting, Philadelphia, Feb. 24–28

Symposium on Paints and Paint Materials to Be Featured; Headquarters Building to Be Dedicated

A SYMPOSIUM on Paints and Paint Materials is to be the technical feature of the 1947 Spring Meeting to be held in Philadelphia at the Benjamin Franklin Hotel on Tuesday, Feb. 25. On Wednesday, Feb. 26, appropriate exercises will be held in connection with the formal dedication of the A.S.T.M. Headquarters Building. Both of these events are scheduled during A.S.T.M. Committee Week which will extend from Monday, Feb. 24, through Friday, Feb. 28, inclusive. During this week there will be a large number of meetings of A.S.T.M. Technical Committees. While a complete schedule of the meetings will be sent to the members in late January, in the meanwhile most of the technical committees convening will also post their members on their respective schedules.

Philadelphia—A Historic and Industrial Center

If it is correct to say that history is "made" then certainly Philadelphia and its citizens have "made" a considerable amount of history. Much of this has had to do with the establishment of our country but history along other than national lines has also been made by the many civic and industrial leaders in later years, and the city and its immediate area have contributed immeasurably to industrial progress. In the sphere of testing machines alone two of the world's largest producers are located in the city and have been for a great many years, and a third leading company no longer located in Philadelphia was established in the city for many decades.

Some facts about the city are noted elsewhere in this Bulletin.

Because of its industrial activity Philadelphia is considered an excellent location for technical meetings, and although no national meetings of A.S.T.M. have been held here since the March, 1935, meeting which by a coincidence also was featured by a symposium on paints, several annual meetings were held in the interim at nearby Atlantic City.

Symposium on Paint and Paint Materials—Tuesday, Feb. 26

Since the 1935 Symposium on Paints there have been a large number of other technical papers and reports presented on protective and decorative coatings at Society meetings, and there was a notable symposium at the 1943 Buffalo meeting, particularly covering wartime applications stressing protective concealment paints, luminous paints, emulsion products and the like. While these papers and technical reports have pointed out many of the more important advances made in the industry and methods of improving as well as evaluating paints and paint materials, it was felt the time was ripe for another comprehensive series of papers. Consequently A.S.T.M. Committee D-1 on Paint,

Looking West on Philadelphia's Parkway toward the Art Museum.

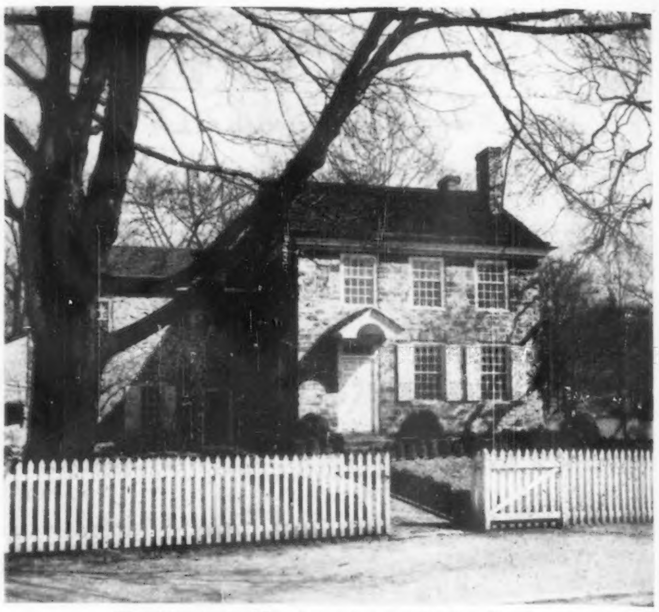
(Photos courtesy Philadelphia Convention Bureau)

Varnish, Lacquer and Related Products has accepted the task of planning the symposium, soliciting the papers and taking care of the many other details involved. Cooperating with the Committee D-1 Papers Committee is the Philadelphia District which will act as hosts during the Spring Meeting. Dr. W. T. Pearce, Consultant on Organic Coatings, Philadelphia, is serving as the Philadelphia District representative on the Symposium Committee, and since he is also Chairman of Committee D-1 this effects a close tie-up. Carlton H. Rose, Member of the A.S.T.M. Board of Directors, and Committee D-1 Secretary, is Chairman of the Symposium Committee, the personnel of which consists of the following:

Carlton H. Rose (*Chairman*), National Lead Co.
P. O. Blackmore, Interchemical Corp.
C. C. Hipkins, Bell Telephone Labs., Inc.
L. A. Melsheimer, United Color & Pigment Dept., Calco Chem. Div., Am. Cyanamid Co.
W. T. Pearce, Consultant on Organic Coatings
M. Van Loo, The Sherwin-Williams Co.

Symposium Plans:

In order to get a consensus on the most important problems which might be covered in the symposium the committee distributed a questionnaire rather widely asking for the viewpoints of many authorities in the field, both producers and consumers. Based on the returns and its own deliberations and discussion, the committee plans to have the symposium in three parts: (*1*) *Statistical*—this would involve a general discussion of the application of statistical analysis and quality control methods, with other discussions covering specific applications in paint testing; (*2*) *Physical Properties of Films*—in this part of the symposium there will be papers covering industrial, automotive and appliance, container and marine finishes, house paints and similar products; (*3*) *Evaluating Paint Materials*—this part of the symposium, it is planned, will involve such topics as viscosity test, evaluation of drying oils, measuring surface area of pigments, and related problems. There will be further detailed announcement of the symposium in the January BULLETIN and each member will receive additional information by direct mail but all those interested are urged to plan now for attending the two sessions at which the symposium papers and discussion will be presented. These sessions are slated for the morning and afternoon of Tuesday Feb. 25, in the ballroom of the Benjamin Franklin Hotel.



Washington's Headquarters at Valley Forge.

It is not planned to have the papers available for distribution in advance of the meeting but some of the material will be distributed at the time of the symposium to those in attendance. Those invited to submit discussion will, of course, be furnished with copies of the respective portions with which they are concerned.

Committee Week

Varying circumstances dictate whether or not a technical Committee will participate in A.S.T.M. Committee Week but this year more than the usual number of technical groups are planning to meet in Philadelphia. Consequently it is expected there will be in excess of 150 meetings, and an effort will be made to schedule them in such a way as to keep conflicts of overlapping membership to a minimum.

One of the reasons why a number of technical committees which heretofore have not participated in Committee Week are doing so in 1947 is the desire on the part of the Board of Directors to have as many members as possible visit the headquarters building to be dedicated officially on Feb. 26.

In addition to a schedule of meetings of the respective committees which each group sends to its own members, a master schedule of meetings will be mailed to each member and committee member in the Society about January 24.

Hotel Reservations

The Benjamin Franklin Hotel is the official headquarters hotel for the Spring Meeting and Committee Week, and its management has agreed to set aside a large block of sleeping rooms. However, it is expected the hotel cannot take care of all of the large number of members anticipated, and consequently seven other hotels are cooperating including the Bellevue-Stratford, Adelphia, Sylvania, St. James, Essex, Warwick and Sheraton, these hotels being located relatively near to the Benjamin Franklin. Some members have other favorite hotels they use while in Philadelphia and reservations can be made directly with them. Members who wish to write early for accommodations can do so but there will be sent to each member early in January a hotel reservation form which he can return giving his requirements.

PHILADELPHIA

A Bit of History and Something About Its Industry

Philadelphia was laid out in July 1682. William Penn selected the name for his new town because of certain passages in the Book of Revelation which refer to Philadelphia in Asia Minor as a City of Brotherly Love. While there was no fixed settlement before Penn arrived, the Dutch and Swedes had visited the site before 1650. In 80 years, that is, by 1760, the population was about 18,000. Shortly after Philadelphia was founded, Germantown was settled by immigrants from Germany. In 1690 the first paper mill in America was built by William Rittenhouse (John K. Rittenhouse, A.S.T.M. Treasurer, and many hundreds of the other Rittenhouses in this country trace their lineage back to William). Andrew Bradford here published the first newspaper in the Middle Colonies beginning in 1719. The American Philosophical Society was established in 1743, and in 1753 the world-famous Liberty Bell was hung in the State House which was built in 1735. When the bell was tested on arrival (not an A.S.T.M. test) it cracked and was re-cast, being used on numerous occasions to notify the populace of important civic events and gatherings, and, of course, the highlight of its use came when in 1776, the Declaration of Independence was announced; the bell cracked again in 1835.

Industry

Philadelphia has an enviable reputation as an industrial city both with respect to the quantity and the quality of its products. Its leading industries are textiles and metals. In 1940 the value of its metal and metal products was close to \$400,000,000, with textiles about \$335,000,000; food and kindred products was about \$260,000,000. During the war time there was a tremendous output from Philadelphia's plants of arms and equipment so essential in the war effort. At Frankford Arsenal and key plants there was an unceasing and early production of arms and ammunition of all kinds, heavy guns, ships—both transport and war vessels, and all the equipment pertaining thereto. Statistics show that for Philadelphia County alone, which would exclude hundreds of establishments in nearby communities, there are over 5300 companies, employing well over 300,000 people.

Education

While the University of Pennsylvania, organized as the Charity School in 1740, becoming the University in 1779, is the city's oldest and largest college, Temple University, founded in 1884, Jefferson Medical College, and numerous other smaller schools attract thousands of students annually.

Independence Hall

Points of Interest

To describe even a few of the large number of points of interest in the city is beyond the scope and reason of this article. The area from Ninth Street to the Delaware bordering on Market, Chestnut and Walnut Streets, alone would merit days of sightseeing and study. At Ninth and Chestnut where the A.S.T.M. Headquarters Hotel, the Benjamin Franklin, is located, was in early days the Continental Hotel. Here Reade wrote "Sheridan's Ride" and Charles Dickens stopped. Close by is the Walnut Street Theater, the oldest theater building still standing in America dating from 1808. The elder Booth, Bernhardt, Drew, Hopper all played here. Further south on Ninth at Pine is the Pennsylvania Hospital, the first hospital in this country. Washington Square, now a beautifully landscaped spot, was the burial ground for hundreds of Revolutionary soldiers and the large number of yellow fever victims. Adjoining is the home of America's oldest magazine, *The Saturday Evening Post*, which is traced back to the *Pennsylvania Gazette* founded by Franklin in 1728. Here, too, is the Philadelphia Saving Fund Society, America's oldest savings bank.

But probably most visited of all Philadelphia's historic and other shrines is Independence Hall, America's national shrine. We wonder how many Philadelphians even know that in the Independence Square are 56 antique gas lamps, one for each signer of the Declaration of Independence, and that there are 13 red oaks, each a symbol of one of the original Colonies, each tree being nourished by soil from the State each tree represents. Congress Hall which adjoins was used by the Federal Congress when Philadelphia was the capital of the nation, 1790–1800.

Other points of interest in Philadelphia include the Franklin Institute with its museum, planetarium, and many scientific and industrial exhibits, and the Academy of Natural Sciences which has splendid exhibits of animal and plant life. (If one gets to either of these places, it is just a few steps to A.S.T.M. Headquarters.)

There are many dozens of other homes and buildings and sites which would repay visits and study by anyone interested. For those who desire, a relatively new booklet has been published by the Philadelphia Transportation Company entitled "Philadelphia 'Green Countrie Towne' and Modern Metropolis," copy of which can be obtained by writing to the PTC, 1405 Locust Street, Philadelphia 2.

Fiftieth Annual Meeting, Atlantic City, June 16 to 20, 1947

General Theme to be "Fifty Years of Progress and the Outlook for the Future"

It is indeed quite a coincidence that after a lapse of several years a return of "old home week" for many A.S.T.M. members in Chalfonte-Haddon Hall should feature the Fiftieth Annual Meeting of the Society. To many of the newer members this will be their first experience of an annual meeting held in Chalfonte-Haddon Hall, which hotel has just received its "discharge papers" from the United States Army with which it has served since the beginning of the war as a base hospital. The "old timers" will be pleased to see the old charm of former years restored in every detail, for the management of the hotel has gone to great length to see that every table, chair, and even each ash tray is returned to its former familiar spot.

Technical Program

The Fiftieth Annual Meeting will follow the general theme of Fifty Years of Progress and the Outlook for the Future, and it is planned to devote at least one technical session to this subject. Many of the technical sessions will feature symposiums, as, for example, those on soils, water-formed deposits, rubber, and fatigue. In addition, the ever increasing number of individual technical papers is expected to round out another interesting and instructive technical meeting. It is again planned to concentrate the presentation of committee reports in a few sessions, which provides some time for the presentation and discussion of technical papers.

While the committee appointed by the Board of Directors to select the Marburg Lecturer has not as yet made its final selection, it is planned to secure a lecturer to speak on a subject which will fit in the general theme of the Fiftieth Annual Meeting.

Final announcement concerning the program will be made later, since there are always a number of details to be coordinated. As has been the normal practice, many of the papers and numerous committee reports will be preprinted and distributed in advance. (Members should keep in mind also that under the new publication policy an effort is made to distribute papers and other material at intervals throughout the year and not all of the material is concentrated prior to the annual meeting.)

Hotel Accommodations

The fixing of the dates, June 16 to 20, a week earlier than our usual annual meeting date, was done to take advantage of a week relatively free of other meetings in Atlantic City, so that we could be assured of the maximum number of sleeping rooms. The attendance at annual meetings now surpasses the capacity of Chalfonte-Haddon Hall so it is necessary to secure room commitments from neighboring hotels which has been done. All reservations will be handled through Chalfonte-Haddon Hall—there will be no housing bureau. The usual room reservation form together with an outline of the program will be sent to all members early next year, but those who are planning to spend the whole week at the meeting may wish to make their reservations now.

Important New Actions on Standards

Non-Ferrous Metals, Clay Tile, Electrical Insulating Materials, Welding Electrodes, Aluminum and Magnesium, and Petroleum Tests

Acting through the Administrative Committee on Standards the Society has recently approved quite a number of new and revised specifications and test methods. The accompanying table lists those which have been acted on during the past few weeks, the dates of approval of the respective items being indicated. It will be noted that the recommendations for these various standardization developments come from technical committees covering a rather wide range of materials.

An effort is made in the article which follows to give some idea of the nature of the new and revised tentatives. All of these will be included in the 1946 Book of Standards, and the specifications and tests will be available in separate pamphlet form either before the big books are issued or immediately thereafter.

Non-Ferrous Metals and Alloys:

The new Tentative Specification covering Fire-Refined Copper for Wrought Alloys (B 216) essentially replaces the Emergency Specification ES-7 developed as a wartime measure and widely used to cover a large variety of applications. The types of copper covered, largely the so-called Braden type from South America and the Morenci type from Southwestern United States, are considered quite suitable for most applications with the notable exception of uses where electrical conductivity calls for a very high purity material. The permissible noncopper elements in the requirements on chemical composition for fire-refined copper are such that the material is not the best available to conduct electricity.

Two other important recommendations from Committee B-2 on Non-

Ferrous Metals and Alloys involve a new Tentative Specification for Soft Solder Metal (B – 32) which replaces the former specification carrying the designation B 32 – 40 T, and a significant new Tentative for White Metal-Bearing Alloys (known commercially as Babbitt metal) which also will replace the current standard B – 23 which has not been revised in twenty years.

The new Solder Specification embodies a number of improvements in arrangement of the specification, incorporates an interesting new system of nomenclature, and essentially will channel the grades into the more widely used commercial alloys. The new grade classification symbol uses numerals to indicate the nominal percentage of tin, followed by the letter A, B, or C indicating the general grading of purity of the solder, A being the highest type, B next in line, and the C grade having a specified antimony content. Some 28 grades of tin lead, tin lead antimony, and silver lead alloys are covered.

The new Babbitt Specifications B 23 – 46 T cover 14 typical Babbitt metals including a number of newer lead-base alloys and others comprising some of the more satisfactory compositions that formerly were covered in emergency requirements for wartime use.

Actions by the A.S.T.M. Administrative Committee on Standards, November, 1946

New Tentatives

Specifications for:

- Aluminum-Base Alloys in Ingot Form for Use in the Manufacture of Castings (B 179 – 46 T), accepted November 6.
- Fire-Refined Copper for Wrought Alloys (B 216 – 46 T), accepted November 25.
- White Metal Bearing Alloys (B 23 – 46 T), accepted November 25.
- Structural Clay Facing Tile (B 212 – 46 T), accepted November 23.
- Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Electrodes (A 298 – 46 T), accepted November 23.

Method of:

- Test for Normal Pentane and Benzene Insolubles in Used Lubricating Oils (D 893 – 46 T), accepted November 6.
- Test for Sulfur in Lubricating Oils Containing Additives and in Additive Concentrates by Bomb Method (D 894 – 46 T), accepted November 6.
- Testing Electrical Insulating Oils (D 117 – 46 T), accepted November 23.
- Testing Askarels (D 901 – 46 T), accepted November 23.

Revision of Tentatives

Specifications for:

- Aluminum and Aluminum-Alloy Sheet and Plate (B 209 – 46 T), accepted November 6.
- Magnesium-Base Alloy Sheet (B 90 – 46 T), accepted November 6.
- Aluminum for Use in Iron and Steel Manufacture (B 37 – 46 T), accepted November 6.
- Aluminum-Base Alloy Sand Castings (B 26 – 46 T), accepted November 6.
- Aluminum-Base Alloy Permanent Mold Castings (B 208 – 46 T), accepted November 6.
- Soft Solder Metal (B 32 – 46 T), accepted November 25.

Method of:

- Sampling and Testing Untreated Paper Used in Electrical Insulation (D 202 – 46 T), accepted November 23.
- Testing Vulcanized Fiber Used for Electrical Insulation (D 619 – 46 T), accepted November 23.

Aluminum and Magnesium

During the year Committee B-7 on Light Metals and Alloys, Cast and Wrought, covering largely aluminum and magnesium and their alloys, has given its numerous specifications very exhaustive study, and in addition to the several actions noted below there were many reported at the Society's Annual Meeting in June. While in general all of the new and revised specifications bring them currently in line with commercial practice, some significant points are worth noting. The new tentative requirements for Aluminum-Base Alloys in Ingot Form for Use in Manufacturing Castings (B 179) essentially consolidate and replace three former specifications (B 58, B 112, and B 125). The same form and essentially the same wording are used as in the now obsolete specifications but some clarifying editorial changes have been made. Some 26 alloys are covered.

The revisions in the Sheet Specifications (B 209 and B 90) correct certain errors made in earlier drafts of the specifications and in the case of the magnesium material, Alloy AZ61X, which is no longer commercially available, is being cancelled.

The requirements for Aluminum for Use in Iron and Steel Manufacture (B 37) will now cover five grades of material ranging from 85 to 98+ per cent aluminum. Requirements are given on permissible copper, zinc, and magnesium, and the sum of the total of impurities. The modified requirements for Aluminum-Base Alloys Sand Castings (B 26) not only incorporate numerous changes in chemical composition but also embody four new alloys. Explanatory notes are added indicating particular properties and characteristics of these.

Similarly, in Specifications for Permanent Mold Aluminum Castings (B 108) six new grades are included.

Petroleum Products and Lubricants:

The two new methods covering Determination of Sulfur in Lubricating Oils which Contain Additives and the Test for Normal Pentane and Benzene Insolubles in Used Lubricating Oils have been under consideration for some time in Committee D-2, the sulfur method having been published for information in the 1946 Report whereas the method pertaining to used lubricating oils was issued as an Emergency Standard (ES 42) in 1944, having been withdrawn in March of this year.

The new Sulfur Method D 894 is intended for both new and used lubricating oils which have additives. The sample is oxidized by combustion in a bomb containing oxygen, under pressure. The sulfur, as sulfate in the bomb washings, is determined gravimetrically as barium sulfate.

The new Methods D 893 not only outline the procedures to be used but incorporate certain significant definitions, for example, a "used lubricating oil" is defined as "the oil and suspended contaminating matter which circulates through a lubricating oil system during operation and which can be drawn from the oil system during or immediately following a period of operation; it does not include deposits in the system or large contaminating par-

ticles which may have separated from the oil in the system." There are definitions of normal pentane insolubles, benzene or "extrinsic" insolubles and other terms. The method outlined indicates that a sample of used lubricating oil is mixed with *n*-pentane, and the mixture centrifuged. The oil solution is decanted, and the precipitate is washed with either *n*-pentane or benzene, as required, dried, and weighed. The inorganic insolubles are determined by oxidizing the benzene insolubles with HNO_3 and H_2SO_4, fuming off the excess acids, igniting, and weighing the residue.

Clay Facing Tile:

These new specifications developed in Committee C-15 on Manufactured Masonry Units cover an important building unit now in use and are a companion standard to the specification for facing *brick* which is in process of promulgation. The requirements cover two types and two grades of tile. One (FTX), a smooth face material where low absorption, easy cleaning, and resistance to staining are required; also where a high degree of mechanical perfection and close dimensions are desired. The second type (FTS) may be a smooth or rough texture face and involves moderate absorption, moderate variation in dimensions and where minor defects in finish are not objectionable.

The two grades of facing tile are the standard and heavy duty.

Electrical Insulating Materials:

The revision in the methods of sampling and testing untreated paper (D 202) involves the addition of a method of testing pH of paper. The method is designed to indicate the active acidity and alkalinity of aqueous extracts of electrical insulating papers. Such extracts are normally unbuffered and are readily affected by atmospheric carbon dioxide. This procedure embodies features to prevent errors from this cause. The method consists of a hot water extraction of the specimen followed by a pH measurement of the cooled extract solution in an atmosphere of nitrogen. The pH measurement involves the use of a glass-calomel electrode system with suitable potentiometric equipment.

The revision in the tests of vulcanized fiber (D 619) are minor, involving the incorporation of a referee test for conditioning in case of dispute. The new tentative methods of evaluating insulating oils will eventually replace the existing method D 17. They are based on extensive work carried out in Committee D-9 where Subcommittee IV on Liquid Insulation has carried out a considerable amount of research, some of it involving a series of round-robin tests.

The new methods of testing askarels (D 901-46 T) are essentially the same as were published for information in the 1943 and 1945 reports of Committee D-9. Requirements cover sampling, determination of various properties, such as specific gravity, color, viscosity and dielectric strength.

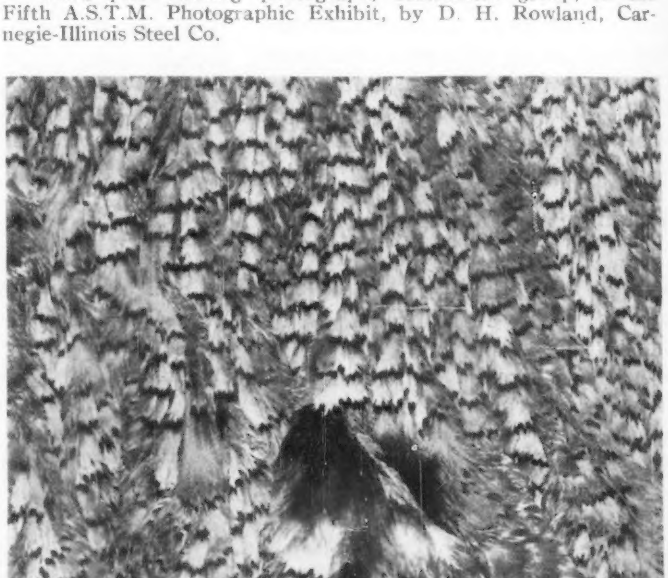
Stainless Welding Electrodes:

Developed in the joint A.W.S.-A.S.T.M. Committee on Filler Metal, these new specifications for corrosion-resistant chromium and chromium-nickel steel electrodes have been in course of promulgation since 1940, when the subcommittee was first organized. A rather complete draft was issued about a year ago and has since been carefully considered and revised. The arrangement of the specifications and the general method of handling the requirements are patterned after the existing standard on iron and steel arc-welding electrodes A 233. The test requirements set up minimum quality levels which will assure suitability for the usual applications. A guide to the specifications is appended which is intended to aid in a proper evaluation and use of the six series which are covered.

"Etched Melted Electrolytic Tin Plate Surface, X2, Unusual Structure"

(Reduced one third in printing)

Third prize-winning photograph, semi-micro group, in the Fifth A.S.T.M. Photographic Exhibit, by D. H. Rowland, Carnegie-Illinois Steel Co.



Concrete Flooring with Asphalt Admixture*

By F. O. Anderegg[1]

SYNOPSIS

Portland-cement concrete floors, due to their hardness and rigidity, have been the cause of much physical disability and discomfort, such as fallen arches and leg and back ailments, to people and animals using them continuously in shops and agricultural buildings. On the other hand, asphaltic floors are likely to be too easily deformed and indented, as well as being expensive when applied as toppings over concrete bases.

A suitable combination of cement and asphalt will produce a floor with much better cushioning effect than straight portland-cement concrete and capable of giving satisfactory service. In the system developed, the asphalt is present as a discontinuous phase.

The resultant alteration of the rheological properties of the concrete are discussed. Procedures are given which were developed in laying a series of floors in several farm buildings and in a large laboratory, with physical properties of the floor mixtures being reported.

THE John B. Pierce Foundation has devoted attention to the problem of flooring as part of its program of reducing costs and improving quality in building materials and methods. Consideration has been given to stabilized earth or aggregate flooring along the lines followed in road work; but the service obtainable has not been considered acceptable for either domestic or agricultural floors. It has been found, however, that a combination of portland cement asphalt and aggregate could be used in laying a floor which resists indention much better than an asphalt floor, while markedly reducing the spine jarring impact of the straight cement concrete floor.

The mix developed results in a system in which the asphalt is the discontinuous phase, the particles of asphalt as observed under the microscope being dispersed in the concrete in the same state of subdivision as in the emulsion added. This is distinct from floor patching cements where cement and sand are added to an emulsion and where the asphalt is the continuous phase.

PROCEDURE AND DISCUSSION

In the earlier work with low binder contents, it was found that a gap grading of aggregate, assembled with optimum amount of water in a technique similar to that used for determining the moisture density relations of soils in Tentative Method of Test for Moisture-Density Relations of Soils (D 698 – 42 T)[2] provided maximum stability of the system against compressive loads, wear, or penetration. Such a grading has been generally used in all experiments and in actual floor installations. In most cases the coarse aggregate has passed a ¾-in. sieve, but has been retained on a ⅜-in. sieve. If, however, the thickness of the floor ranged from 1 to 1½ in., the next smaller size was used. The larger size, of course, contributes a higher compressive strength. Gravel and a variety of crushed stone, as well as crushed slag, have been successfully applied. The preferred material for maximum stability is a crushed product approaching the cubical shape. Various natural, crushed stone, and slag sands have been satisfactorily used, but a minimum of 25 per cent passing the No. 50 sieve is desirable for good workability.

Asphalt as emulsion has been chosen as the most convenient form for the addition of the cushioning agent, although several emulsifying agents are available. Clay emulsions are costly and must be stirred into the mixing water. Some of the protein emulsifiers may interfere with the setting of the cement and may cause bad odors. Vinsol resin provides a nice working emulsion, except that control of the mixing water must be very rigid to prevent foaming. We have used Vinsol resin emulsion, but the variable water content on the aggregates necessitates great care to avoid an excess in the amount of water to be added. An emulsifying agent called "Hydropel"[3] when blended with $\frac{1}{12}$ to $\frac{1}{10}$ its weight of Vinsol resin emulsion, has yielded quite good results. Emulsions made from high-penetration asphalts are easily handled and seem to produce better workability and cushioning action. Their durability ought to be greater than that of the thicker asphalts. Emulsions of coal tars which have been tried have seriously lowered the concrete strengths.

Experimental mixes have been made ranging from 5 to 12½ per cent of cement and from 0 to 5 per cent asphalt emulsion, based on the aggregate weight. Concretes of satisfactory strength have been obtained in the range of 7½ to 12½ per cent cement and with 2 to 3 per cent emulsion.

Table I gives results typical of many others obtained with different aggregates and with different asphalt emulsions. This particular emulsion was prepared, with the aid of Vinsol resin, from 150 to 200-penetration asphalt. The stone was a siliceous stone from a New Jersey iron mine, passing a ¾-in. sieve but retained on a ⅜-in. sieve with a dry, rodded weight of 91 lb. per cu. ft. The sand was a yellow silica sand from Lakewood, N. J., used for concrete purposes. A sieve analysis indicated 27 per cent passing the No. 50 and 4 per cent passing the No. 100 sieve, with a dry, rodded weight of 102 lb. per cu. ft. The cement was typical of type I cements from the Lehigh district.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Forty-Ninth Annual Meeting, Am. Soc. Testing Mats., Buffalo, N.Y., June 24–28, 1946.

[1] Consulting Specialist on Building Materials, John B. Pierce Foundation, Raritan, N. J.

[2] 1944 Book of A.S.T.M. Standards, Part II, p. 1399.

[3] Product of the American Bitumuls Co., San Francisco, Calif.

TABLE I.—RESULTS OF VARIOUS EXPERIMENTAL MIXES.

Batch	Per Cent of Total Aggregate by Weight.		Quantities per Bag of Cement					Flow, per cent	Seven-Day Strengths	
	Cement, per cent	Asphalt, per cent	Stone, lb.	Sand, lb.	Vinsol-Asphalt, gal.	Added Water, gal.	Total Water, gal.		Compressive, psi.	Flexural, psi.
No. 20...	7½	0	645	605	0	11.3	11.3	8	1220	360
No. 21...	7½	2	645	605	2.8	8.5	9.6	8	970	315
No. 22...	7½	3	645	605	4.2	7.5	9.2	5	820	280
No. 30...	10	0	475	465	0	7.5	7.5	10	1870	440
No. 31...	10	2	475	465	1.9	6.9	7.7	10	1700	410
No. 32...	10	3	475	465	2.8	6.3	7.4	10	1510	385
No. 40...	12½	0	380	370	0	5.8	5.8	10	2540	545
No. 41...	12½	2	380	370	1.5	5.3	5.9	10	2260	495
No. 42...	12½	3	380	370	2.2	4.8	5.7	8	1970	475

Similar results have been obtained with other emulsions, except that it seems to require somewhat more clay emulsion to secure a given workability. Under certain conditions, actual improvements have been noted in compressive strengths on adding Hydropel emulsions to regular concrete.

The first practical installations were made in a barn, where one third of the floor area was laid using 4½ bags of portland cement per cubic yard of concrete (mix A); to the same mix, 15 gal. of clay emulsion was added for the second third (mix B); while the last third was paved with concrete containing 15 gal. of emulsion and only 3½ bags of cement (mix C). Slag crushed to pass a 1½-in. sieve and retained on a ¾-in. sieve was used to the extent of 1650 lb. per cu. yd. The same amount of slag sand passing No. 8 sieve was included, of which 25 per cent passed the No. 50 sieve. Mixing was carried out in a 1-cu. yd. transit mixer, sufficient water being added so that the material glistened in the light and would consolidate under a small amount of working. The slump ranged from 0 to ½ in. and the standard flow test was 5 to 10 per cent. Figure 1 illustrates the proper consistency.

For a 4-in. thick floor, ¾-in. strips were temporarily tacked to the grounds, and the concrete was screeded ¾ in. higher than the finish finally desired. It was then rolled with a roller weighing about 125 lb. per linear foot until quite smooth. The concrete should then again be screeded, preferably with a power machine. Sprinkling a little of the same mix, but without the coarse aggregate, in front of the rodder aids in the finishing. The surface could then be finished with a power float, as shown in Fig. 2. The Kelley Electric float was especially useful around edges and obstructions, while a Whiteman float was found to be much faster on larger areas. A second finishing just prior to the initial set produced a fine surface. If still greater smoothness was desired it could be obtained by hand trowelling. When the surface became a little dry, water was sprinkled thereon to

Fig. 1—Proper Consistency for Mixtures Intended for Asphalt Admixtures for Flooring.

The concrete in the immediate background has just been rodded. Note the ¾-in. strip on which the 2 by 4 rod rests. The concrete closely approximates the desired grade on rolling. A second rodding with a little of the mix minus the coarse aggregate placed ahead of the 2 by 4 provides a plane surface which readily smooths out under a power float.

Fig. 2—Compacting the Concrete and Smoothing the Surface with a Kelley Power Float.

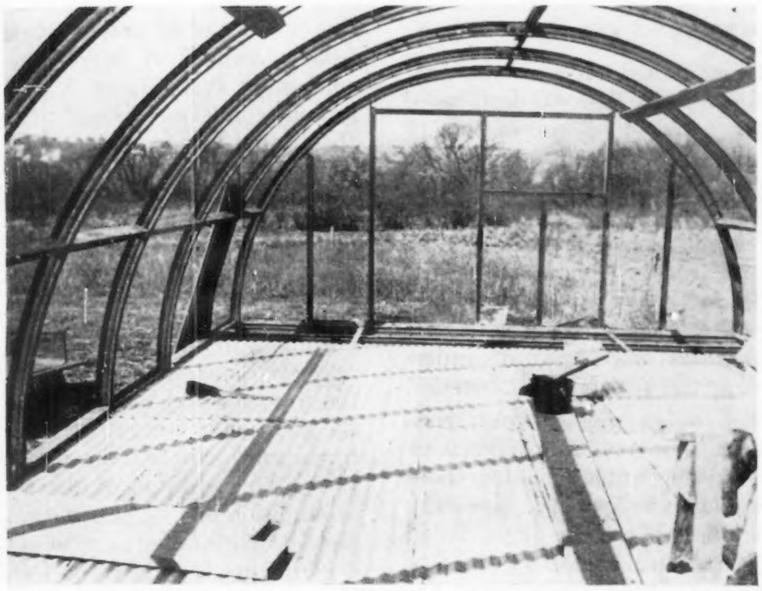


Fig. 3—Corrugated Iron Sheets over Light Stransteel Joists in Brooder House to Be Covered with $1\frac{1}{2}$ in. of Concrete Flooring Containing Asphalt.

facilitate the floating operation. Some of this concrete was molded into cubes for compression test, some into prisms for flexure tests and slabs were also made up for determination of thermal conductivity[4] and wear.[5] The results

TABLE II.—FLOORS OF SLAG CONCRETE WITH AND WITHOUT CLAY-ASPHALT EMULSION.

Mix	Density, lb. per cu. ft.	Compressive Strength, psi.		Flexural Strength, psi.		Thermal Conductivity[a]		Wear,[5] in.	Rebound from 36-in. Drop, in.[b]
		7 days	28 days	7 days	28 days	Dry	Wet		
A	143	2450	....	400	550	5.7	8.8	0.019	6
B......	137	1030	2010	320	450	5.4	6.0	0.020	$2\frac{1}{4}$
C......	137	940	1410	300	400	5.2	5.8	0.031	1
Maple flooring........								0.022	

[a] Btu. per inch per square foot per deg. Fahr.
[b] The rebound was that of a steel ball bearing dropped 36 in. This gives a measure of the amount of mpact energy absorbed.

obtained are given in Table II.

Later a $1\frac{1}{2}$-in. thick roof was poured using $\frac{3}{8}$-in. crushed stone. A poultry brooder house was floored with similar material, the concrete being partly over $\frac{1}{2}$-in. plywood and partly on top of corrugated iron sheet attached to Stransteel joists. Such support (shown in Fig. 3) is rather flexible so that some flexibility in the concrete is desirable. The floor in use is shown in Fig. 4. A floor for a poultry laying house was laid over 2 to 4 in. of crushed stone placed directly on the ground, partly over fill.

Some of this flooring was only 2 in. thick, part being reinforced with No. 16-gage wire 8 in. on center. Expansion joints were placed at 20-ft. intervals. The mixing for these jobs was carried out in a one-bag, stationary mixer. The batch on a volume basis consisted of 1 part cement, $5\frac{1}{2}$ parts damp sand and $8\frac{1}{2}$ parts $\frac{3}{4}$-in. stone with $1\frac{1}{2}$ gal. of clay emulsion and sufficient water to bring the mix to the same consistency as shown in Fig. 1. By weight, the mixes were close to those given just below. Cubes prepared on the job developed about 1500 psi. at 28 days. These floors after continuous use for 1 year are in excellent condition. The chicken litter on these floors did not become wet from condensation during the past winter.

It was then proposed to install similar flooring in the new Housing Research Laboratory. The clay asphalt had given excellent results but it was thick and required stirring thoroughly with part of the mixing water to avoid segregation. It was also rather expensive and the amount required seemed excessive. A Vinsol resin, of course, promotes excessive foaming, but it was found that in the consistency used the foaming was not important. However, if a little too much water was added, foaming became a factor; therefore constant vigilance had to be maintained to keep this under control. The batch used contained 350 lb. of portland cement, 7 gal. of asphalt emulsion (made from 150 to 200-penetration asphalt), together with 2000 lb. of $\frac{3}{4}$-in. trap rock, and either 1800 lb. trap rock screenings or 1600 lb. natural sand, per cubic yard of mix. The dry ingredients were delivered in 5-cu. yd. transit mixers to the job, where the emulsion and additional water were added. This water varied from 40

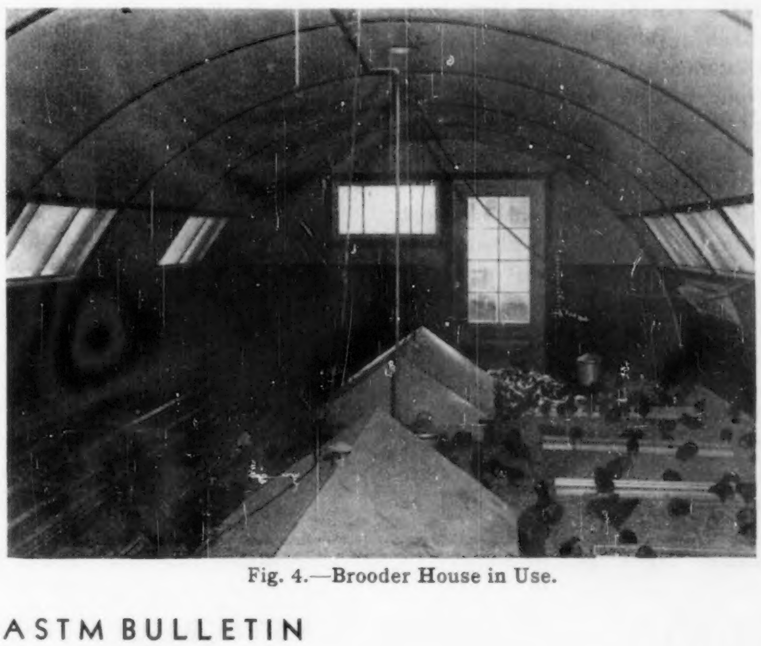


Fig. 4.—Brooder House in Use.

[4] Determined by the Pittsburgh Testing Laboratory, Pittsburgh, Pa.
[5] C. S. Geister, *Journal*, Am. Ceramic Soc., Vol. 9, No. 3 (1926), 5000 revolutions.

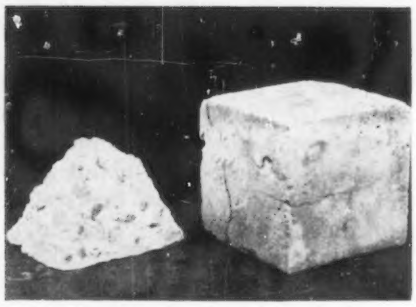


Fig. 5.—Specimens After Compression Testing.

The residue on the left is from a straight concrete cube which had failed explosively, while the one on the right containing 2 per cent asphalt based on the aggregate had withstood a considerable amount of compressing.

to 80 gal. per batch, depending on the wetness of the aggregates.

To facilitate the determination of the amount of additional water required, a bulking curve was determined for the particular fine aggregate by test determinations. Mixing was continued for at least 10 min.

Several cubes were molded from concrete taken from the mixer. The compressive strengths varied from 1000 to 1300 psi. at 7 days and from 1700 to 2000 psi. at 28 days. One set of cubes, broken at three months, averaged 2830 psi., while another set gave the value of 3660 psi. at 6 months.

The first portion of the laboratory floor was laid in August, 1945, and has been in constant use since. It has given excellent service, standing up under rather heavy movement of equipment and yet maintaining considerable comfort for the feet, legs, and back. While we have no quantitative measure of the physiological difference we have noted much less fatigue than was experienced previously in the former laboratory floored with regular concrete.

The problem of improved comfort must be tied in with the absorption of impact energy and that with the rheological properties of the concrete. The rebound of a steel ball gives a measure of the amount of impact energy absorbed. Steel ball bearings allowed to fall 36 in., on smooth regular concrete rebound usually 6 to 10 in., while the rebound from smooth concrete described here containing asphalt (present as a discontinuous phase) is 2 to 5 in.

Observations and Conclusions

At first thought it is a little difficult to see why discrete droplets of asphalt, of a typical size of 5 to 10 microns, should produce this effect of absorption of impact. The main structure of the concrete is apparently similar to any lean concrete, with a rough honeycombing of aggregate cemented by calcium hydrosilicate gel. The following observations may aid in understanding the phenomena observed.

When cubes molded from concretes with or without asphalt were placed in the testing machine, those containing no asphalt, especially when older than seven days, failed with sudden explosive breaks. Those containing asphalt, on the other hand, have required a much longer time before breaking under the head, which was moving at the standard constant speed of 0.05 in. per minute. A great deal of compression took place after the maximum load was reached and the loading continued for some time before the specimen fell apart. Figure 5 shows the residues after such a test. The asphalt particles seem to act as cushions permitting plastic flow. It is suggested that this system behaves as does a regular plastic system. If a plastic (such as the clear phenolic used in three-dimensional photoelastic analysis) is loaded at the proper temperature, the weakest bonds give way first, followed successively by progressive failure of stronger bonds. The resultant distortion is maintained as the specimen cools. It seems to depend upon the statistical contribution of bonds of different strengths varying as it does with the stress.

From these observations it may be concluded that in this system the stress-strain curves may start out about the same, but the presence of the asphalt droplets seems to facilitate flow beyond a certain critical load. Some stress-strain curves for various mixes have been determined and such flow seems to be what is taking place. When asphaltiferous specimens were loaded above 50 per cent of their ultimate strength a "set" or permanent deformation was generally observed.

To compare the weathering qualities, a series of 43 prisms fabricated from a variety of aggregates and containing 0, 2, 3, or 5 per cent asphalt emulsion was half-buried in the ground late in December, 1945. Early in April, 1946, those prisms containing cement to the extent of 7½ per cent or more of the aggregate were generally in good condition. Most of the specimens containing only 5 per cent cement were beginning to fail.

Absorptions were determined on these prisms and it was found that the addition of cement was the most important factor in reducing absorption. The addition of the asphalt as emulsion and its presence as discrete droplets failed in most of these experiments to reduce the total 24-hr. gain in weight while immersed in water; but the rate of imbibing water was often reduced by the presence of the asphalt.

The costs of the concrete are essentially identical with normal 1:2:4 portland-cement concrete for floors, the asphalt cost being taken care of by the reduction in the cement content. The application technique is essentially like that used with floor topping. In this procedure, the strength obtained with the drier mix offsets the weakening effect of the extra water added to the 1:2:4 concrete, as usually applied in this area.

In a series of floors laid in agricultural buildings and in a research laboratory where part of the portland cement in the concrete mixture was replaced by asphalt emulsion, a gap grading of aggregates has been found most desirable and sufficient water added only to produce a 0 to ½-in. slump. A mixture which has seemed to give excellent results required approximately 3½ bags of cement and 7 gal. of asphalt emulsion per cubic yard of concrete, the ratio of sand to stone being determined by the necessity of maintaining workability.

Compressive and flexural strengths are generally reduced by the addition of the emulsion, but the latter do not suffer as much apparent loss as the former. The compressibility and flow under load are enhanced; thus the comfort of people working thereon seems to be definitely improved.

Mr. Gershon L. Oliensis.[1]—I have studied asphalt pavements and asphalt flooring for many years and know their tendency to dent under pressure. I am therefore wondering if you put a very heavy machine on your floor on small casters and let it stay there for a week or more, would the flooring indent?

Mr. F. O. Anderegg (*author*).—This combination of materials results in a flooring system in which the portland-cement concrete is the continuous phase and the asphalt is present as a discontinuous phase. The floor has had sufficient rigidity to withstand the pressure exerted by heavy machines which have been in place for over a year with no perceptible indentation. The presence of the asphalt as 2 to 3 per cent by weight of the aggregate seems to give the flooring a "memory." When a concrete cylinder of this material is loaded in compression up to about 800 psi., the compressibility indicated by strain gages is somewhat more than with the control specimens containing no asphalt. But on reloading, the strain gages applied to specimens containing the asphalt show remarkable fluctuations, often actually seeming to indicate expanding forces within the concrete resisting and counterbalancing the increasing loads applied. Similar phenomena have often been observed in systems of organic plastics.

Mr. Oliensis.—I was particularly interested because I, too, have worked with mixtures of portland cement and emulsified asphalt and have found the same thing to be true, that you can get a system whereby you have the rigidity of concrete plus the toughening effect of asphalt in one and the same mixture. I am glad your work has so corroborated my own observations.

Mr. S. H. Ingberg.[2]—I presume some form of rattler test was used?

Mr. Anderegg.—Reference is made in the paper to the type machine used for the abrasion test. A fine, standardized grit was fed between the shoe leather abrading wheel and the specimen.

Mr. Ingberg.—Is the wear greater or less for the same mix of concrete?

Mr. Anderegg.—The wear in the specimens seemed to depend upon the cement content; but the amount of water used, as well as the nature and grading of aggregate, are also important factors. Although only 3½ bags of cement are used in a cubic yard of our flooring, careful control of the water content and the use of trap rock or other hard aggregate in a gap grading result in a very satisfactory abrasion resistance, as has been demonstrated by some two years' continuous performance.

Mr. Ingberg.—As compared to the concrete without the admixture, how does it wear?

Mr. Anderegg.—Without admixture it is about fifty per cent better by this test. It is good hard concrete.

Mr. Ingberg (*by letter*).—There apparently is no wear test representative of foot traffic that can be depended on to show even relatively the performance of material such as the one discussed in the paper. The effect of the asphalt under such traffic in the formation and persistence of wearing films may be quite different from that in a test equipment where such films if formed do not persist. The experience with the material in comparison with that of unmodified concrete appears to indicate a better relative performance than shown by results of accelerated wear tests.

Mr. W. H. Price.[3]—Does this concrete containing asphaltic admixtures have a greater resistance to shrinkage cracking than regular portland-cement concrete?

Mr. Anderegg.—We put in expansion joints at about every 20 ft. and that took care of the shrinkage very nicely.

Mr. Price.—What is the comparable extensibility of this concrete containing asphaltic admixtures?

Mr. Anderegg.—We have made a few measurements and have indications that the shrinkages are a little less in our material than in regular concrete. The presence of the asphalt as discrete dispersed droplets should affect the concrete shrinkage only indirectly by reducing the rate of moisture loss.

Mr. Price.—How does the durability of this concrete compare with regular concrete? Have any of your test sections been exposed to the weather?

Mr. Anderegg.—Prisms have been half buried in the ground for 1 yr. So far no difference has become apparent resulting from asphalt admixture. All specimens containing 7½ per cent cement or more, based on the aggregate weight, are apparently in perfect condition. It is planned to make further observations periodically.

Mr. Benjamin Wilk.[4]—Did you find it necessary to mix the concrete longer with the asphalt in it?

Mr. Anderegg.—Yes, we mix for 10 to 15 min., the dry mix we recommend requiring more mixing than wetter ones would.

Mr. Wilk.—How about strength?

Mr. Anderegg.—Specimens molded from batches actually used in flooring our laboratory acquired compressive strength above 3000 psi. in 6 months.

Mr. L. R. Forbrich.[5]—Do these floors have better resistance to lactic, acetic, or other acids that might be encountered around dairies, breweries, and canning factories?

Mr. Anderegg.—Again you have your concrete system as the main structure and that is susceptible to attacks by the acid. However, it offers somewhat more resistance than ordinary concrete in comparable exposure because the asphalt does give a little protection after the surface has been etched away by the acid.

Mr. Oliensis.—Have you ever studied what would happen if you slowly increased the proportion of the asphalt to the portland cement

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[2] Principal Materials Engineer, National Bureau of Standards, Washington, D. C.

[3] Materials Engineer, Bureau of Reclamation, Denver, Colo.

[4] Vice-President and General Manager, Standard Building Products Co., Detroit, Mich.

[5] Chief Chemist, Green Bag Cement Div., Pittsburgh Coke and Chemical Co., Pittsburgh, Pa.

to see whether you would work into the bituminous system eventually?

MR. ANDEREGG.—We have worked with asphalt as high as 5 per cent based on the aggregate weight and found reduced strength and greater flexibility.

MR. OLIENSIS.—My question would be whether, as you increased the proportion of bitumen, the system would change gradually or would there be a sharp break at some intermediate point?

MR. ANDEREGG.—We have not gone high enough to be able to answer your question.

MR. OLIENSIS.—My own observations have been that there is a slow transition from the concrete system to the bituminous system without any very abrupt break.

MR. C. L. MCKESSON[6] (*presented in written form*).—We are in a reconstruction era. It is most timely and fortunate, therefore, to learn at this time of improvements in materials of construction such as presented by Mr. Anderegg in this paper. We are all conscious of our many miles of excellent bituminous and concrete pavements. It may have occurred to some of us, though, that the ideal pavement might be realized by a cross between these two commonly used building materials. Mr. Anderegg has blazed this trail for us in showing that a superior floor from the standpoint of resilience, toughness, and lowered thermal conductivity may be obtained from suitable combinations of cement, emulsified asphalt, and aggregate.

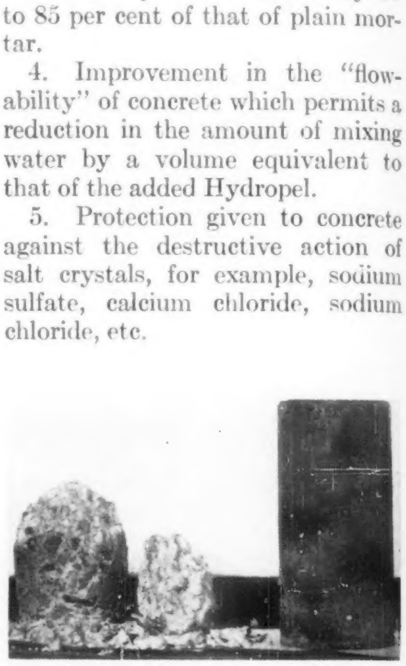
It is well to point out that all emulsified asphalts do not work equally well for this purpose. Emulsified asphalts of the types normally specified for paving and other uses seriously impair the natural strength of the concrete. Emulsified asphalts of the Vinsol resin type, when used alone, cause excessive foaming and if not handled with extreme care will result in a sponge-like structure in the concrete.

Mr. Anderegg in his paper refers to an emulsified asphalt marketed under the trade name of Hydropel and especially designed for this purpose. This product, by imparting increased workability to concrete, permits of lowering of water-cement ratio and is used in sufficient quantities to reduce absorption of concrete without seriously impairing the structural strength of the concrete. Tests conducted at Stanford University over a period of years show that no retrogression in strength results from its use. Vinsol types of emulsified asphalt, as before stated, produce a spongey air-filled concrete. Highest structural strength is not always essential in floors, but resilience, moisture, and thermal resistance are important. The proposal by Mr. Anderegg of the combination of the Hydropel type of admixture with the air-entraining Vinsol type of emulsified asphalt seems most reasonable. The recommended blend of one part Vinsol resin asphalt emulsion with ten parts Hydropel emulsified asphalt should give desirable floor characteristics without a too serious loss in the strength of the concrete.

The resistance to abrasion of asphalt plasticized concrete floors of this type would naturally be expected to be considerably greater than that of plain concrete of identical cement content. One way to demonstrate this is through the lower coefficient of wear when identical specimens are exposed to the action of a sand blast for short time periods. In a test of this type, the asphalt-treated concrete showed 15 per cent less wear than plain concrete. We believe that Mr. Anderegg has made not only a very worth-while contribution to flooring construction, but also to many other fields where plain concrete is not the ideal construction material. His teaching might well receive attention in the concrete paving field.

MR. P. E. MCCOY[7] (*presented in written form*).—In Mr. Anderegg's very interesting paper, the improved comfort obtained through the addition of emulsified asphalt admixture to concrete flooring is discussed. This is, however, only one of the advantages wh ch we have found through incorporating asphalt in this form in concrete. A few of these additional contributions are:

1. An aid to the curing of concrete which would serve to eliminate the normal puddling and earth cure required in the placement of plain concrete.
2. Improved impact and flexural strength in lean concrete.
3. Reduction in the capillary water absorption of mortar by 80 to 85 per cent of that of plain mortar.
4. Improvement in the "flowability" of concrete which permits a reduction in the amount of mixing water by a volume equivalent to that of the added Hydropel.
5. Protection given to concrete against the destructive action of salt crystals, for example, sodium sulfate, calcium chloride, sodium chloride, etc.



Untreated concrete Hydropel treated concrete

Fig. 6.—Appearance at 10 Cycles.

The effectiveness of concrete containing asphalt admixture against the spalling action of salts is shown by subjecting the cured emulsified asphalt-treated concrete and plain concrete specimens to an adaptation of the A.S.T.M. soundness test for aggregate. This modified test consists of alternate cycles of immersion of treated and untreated concrete specimens in saturated sodium sulfate solution followed by conditioning in a dry atmosphere (140 F. oven), the test cycle to comprise 3 days' immersion, 3 days' dry atmosphere followed by brushing loose any disintegrated matter from the specimens. Plain concrete, after 10 cycles of this treatment, was almost completely disintegrated, whereas the concrete containing emulsified asphalt admixture remained intact (see accompanying Fig. 6).

MR. JOHN TUCKER, JR.[8] (*by let-*

[6] Vice-President and Director of Engineering and Research, American Bitumuls Co., Los Angeles, Calif.; now Research and Engineering Consultant, Los Angles, Calif.

[7] Research Engineer, American Bitumuls Co., San Francisco, Calif.

[8] Chief, Concreting Materials Section, National Bureau of Standards, Washington, D. C.

ter).—Mr. Anderegg's condemnation of the portland-cement concrete floor is entirely too comprehensive. It is admitted that there is a considerable objection to the concrete floor because of its hardness and its coldness in winter, but a careful search of medical literature fails to reveal a single statement blaming concrete floors for "causing fallen arches," as Mr. Anderegg states. The literature limits itself to the opinion that those with fallen arches find walking on a concrete or other hard surface floor objectionable.

Unfortunately, there appear to be absolutely no experimental data based on physiological test measurements of the actual effects of floors upon those using them as walking surfaces. DallaValle[9] lists the indentations of various floor surfacings under a standard loading and adds that the degree of discomfort would vary inversely with the indentation. However, in the writer's opinion, the indentation under ordinary walking is so small that it is inconceivable that anyone could be so sensitive of perception as to be aware of the small differences in most of the common floor surfacings such as concrete, wood, magnesium-oxychloride cement, or linoleum. It is possible, however, that the degree of discomfort is determined to some extent by the degree of indentation, since this may be regarded as an index of energy dissipation in the flooring material.

Again, we must differentiate between the rigidity of the floor material itself, and of the floor structure. A concrete floor is unyielding, whereas for most wooden floors, the supporting structure, also of wood, under ordinary walking deflects many times the indentation value of the material under similar pressure.

The concrete floor is resonant and anyone walking in a room with a concrete floor becomes aware before long of the hardness of the floor, through hearing perception. The noise of walking or the sharp sound of metal objects falling upon or striking the floor will give this impression of hardness. Thus the worker gains the idea that the floor is hard, and therefore it seems natural to him that it is an unpleasant surface upon which to walk. Possibly the bodily fatigue caused by working on concrete floors is actually caused through the sense of hearing. If so, a cure lies in the application of sound-absorbing material to the walls and to the ceilings.

Mr. A. W. Attwooll[10] (*by letter*).—While there have been various investigations undertaken in England, I think it can be said that none of them has so far produced a material which shows the positive advantages claimed by Mr. Anderegg. We believe that Mr. Anderegg is correct when he attributes the success of his mixtures to be dependent very largely on the type of emulsion employed: we propose to reexamine this question on the basis of the Vinsol resin emulsions.

We note that it is suggested on page 12 that a finishing can be obtained by using the mortar without the introduction of the coarse aggregate. Has the author any evidence to show that this fine mortar without coarse aggregate gives equal resistance to foot traffic without undue wear or tendency to crack and break up? This in our view is an important point as it opens up an enlarged field of application and we should welcome any information which may be available on this point.

Mr. Anderegg (*author's closure by letter*).—Mr. McCoy lists several other advantages from asphaltic admixtures which seem well worthwhile. We have found marked decreases in moisture absorption on adding Hypropel asphalt and Hypropel-Vinsol blended asphalts. These seem to be better in this regard than a clay emulsion we used in earlier applications.

Mr. Tucker questions the fatigue produced by walking and standing on concrete floors. It is very difficult to make a quantitative measure of such effects. It has been suggested such contacts result in fatigue of the nerves in the joint sacks, and that suitable observations might give some semiquantitative indications. This matter is under study by L. P. Harrington in our Laboratory of Hygiene and it is hoped to set up experiments which may shed light on this difficult question. In the meantime, we can only cite our own experience after two years on straight concrete and one year on our present floor. Maintenance engineers get frequent complaints from workmen because of concrete floors causing fatigue. It is believed that the rebound of a steel ball, giving a quantitative measure of the absorption of energy of impact, is useful in evaluating comfort.

In answer to Mr. Attwooll's question, we used only a small amount of mortar mix to fill in a few irregularities in the concrete and two years of constant use have failed to develop any difference between adjacent areas with and without the mortar.

The interesting rheological properties of this system are under investigation and it is hoped to be able to elucidate the phenomena so far observed.

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[9] J. M. DallaValle, "Sanitary and Physiological Aspects of Floor Coverings," *U. S. Public Health Reports*, Vol. 55, October 18, 1940, pp. 1884–1892.

[10] Chief Technical Adviser, The Limmer and Trinidad Lake Asphalt Co., Ltd., London, England.

The Falling Sand Abrasion Tester

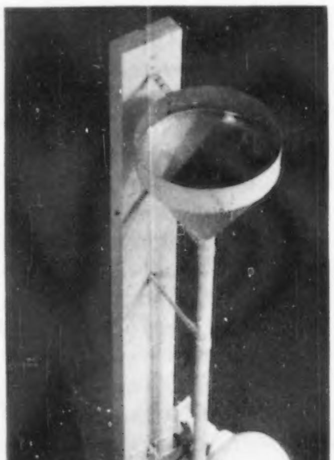
By C. C. Hipkins[1] and R. J. Phair[1]

Because of its simplicity, the falling sand method for determining the abrasion resistance of applied organic coatings has been quite widely used. One method[2] involves allowing nearly spherical particles of sand to fall a definite distance through a guide tube onto the surface of the coated specimen until the film is worn away exposing a small area of the base metal. The amount of sand required is the measure of abrasion resistance.

Its use in Government specifications during the war indicated a decided need for standardization of both the apparatus itself and the testing procedures employed. With this objective, a cooperative series of tests were conducted by the Technical Committee of Protective and Technical Coatings, Chemical Division, War Production Board, and it is the purpose of this paper to present the results obtained, to discuss some of the variables encountered, to show that reproducibility is possible, and to propose a simple construction and procedure which may be considered as a basis for standardization.

In the tests, specimens of a baked phenolic varnish applied to smooth cold-rolled steel were prepared by two of the participants and were distributed to the thirteen collaborating laboratories. In one case the automatic spray method of application was employed to give a uniform film thickness of 0.00045 ± 0.00003 in., while in the other case a dipping method was employed to obtain films of the same thickness. In addition to the normal baking conditions for the varnish employed, films prepared by the latter laboratory were purposely overbaked and underbaked by 25 F.

The panels after being tested by the different laboratories in accordance with the method for abrasion resistance as then given in a particular AXS specification were all returned to one participant together with particulars as to the construction of the apparatus employed and the procedure followed. The data obtained were rather voluminous and have been condensed in Table I to show only average abrasion-resistance values obtained and the rates of flow of sand employed.



The Falling Sand Abrasion Tester.

Analysis of these abrasion-resistance data indicated three general classifications of abrasion results. In one group indicated in the table by "+" the values obtained averaged about 13 liters. A second group indicated by "X" varied from 23 to 30 liters. In these two groups the area worn through to the base metal was centrally located within the abrasion pattern. Those at variance with this form of wear end point or which had excessively high abrasion resistance values were segregated in group 3. Although some specimens in this group did have centrally located wear spots, the majority were considered to have failed when the sand broke through at the top of the abrasion pattern. Reasons for this type of failure are discussed in a later section of the paper.

Representative panels of each of the three groups as shown in Fig. 1 indicated that misinterpretations by some collaborators as to the construction of the apparatus and the testing procedure were responsible for the nonagreement in data ob-

TABLE I.—COOPERATIVE STANDARDIZATION TESTS ON FALLING SAND ABRASION TESTER.

Summary of Average Abrasion Resistances (Liters of Sand)

Participant	On Panels Prepared by Participant E: 1, 25 F. Underbake	2, Normal Bake	3, 25 F. Overbake	On Panels Prepared by Participant C	Flow of Sand, sec. per 5 Liters
A	..	..	..	11 (+)	61
				14	46
B	30	26	26	28 (X)	52
C	12	13	13	13 (+)	59
D	10[a]	18[a]	1[illegible]	28	45
	6[a]	14[a]	14[a]	20[a]	60
E	30[a]	35[a]	35[a]	30[a]	50
F	..	..	..	23 (X)	40
G	13	13	14	14 (+)	52
H	16[a]	24[a]	42	..	?
I	6[a]	15[a]	17[a]	19[a]	52
J	14	12	13	14 (+)	52 to 56
K	17[a]	22	30	27 (X)	55
L	..	..	..	8[a]	?
M	20[a]	60	54	48	50

[a] Results were apparently not tested as per specification. In the majority of such cases break-through occurred at top of abraded area only, and in some few instances practically no break-through was realized.

The flow rates in the cases of participants A and D were purposely varied between the limits 45 to 60 sec. to determine the effect on abrasion resistance obtained within these limits.

In the cases of participants C, G, and J in which the flow rates varied between 52 and 59 seconds the maximum variation in any one group of panels based on individual readings was ±14 per cent. The maximum variation based on averages for the same panels was ±7.5 per cent.

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[1] Bell Telephone Laboratories, Inc., New York, N. Y.

[2] G. G. Sward, Scientific Section, Am. Paint and Varnish Mfg. Assn., Circular 353, July, 1929; and U. S. Army Ord. Spec. AXS 736 (Varnish, Phenolic-Baked), Rev. 1, Section F-3J.

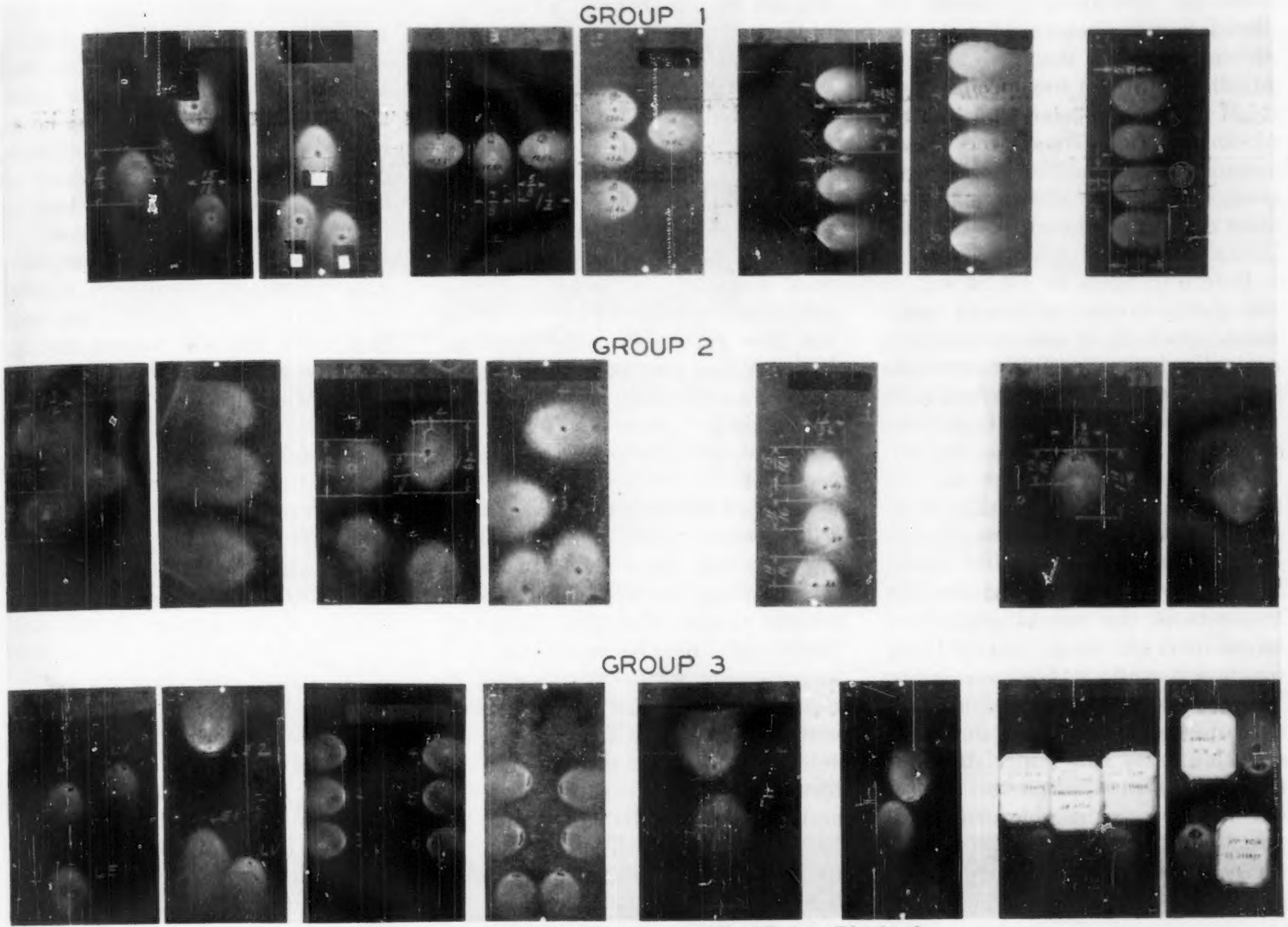

Fig. 1.—Representative Specimens of End Points Obtained.

tained. The panels in group 1 (the top line of panels) had sharp well-defined wear patterns with an over-all abraded area $\frac{15}{16}$ in. in maximum width and $1\frac{15}{16}$ in. in maximum length. The end points in this group were based on the appearance of a worn area at the approximate center of the wear pattern. The construction of one machine, utilized in obtaining some of the data in this group, was definitely known and is illustrated in Fig. 2 (*a*). It was assumed that because of the comparable results obtained, the other machines employed in obtaining the results in group 1 were essentially similar in construction and operation. It was interesting to note that even in this group some variations occurred and appeared to be a function of the flow rate of the sand, as shown below:

Participant	Abrasion Resistance, liters of sand	Flow, sec. per 5 liters
A	14.38	46
G	13.48	52
J	14.20	56
C	12.78	58
A	10.53	61

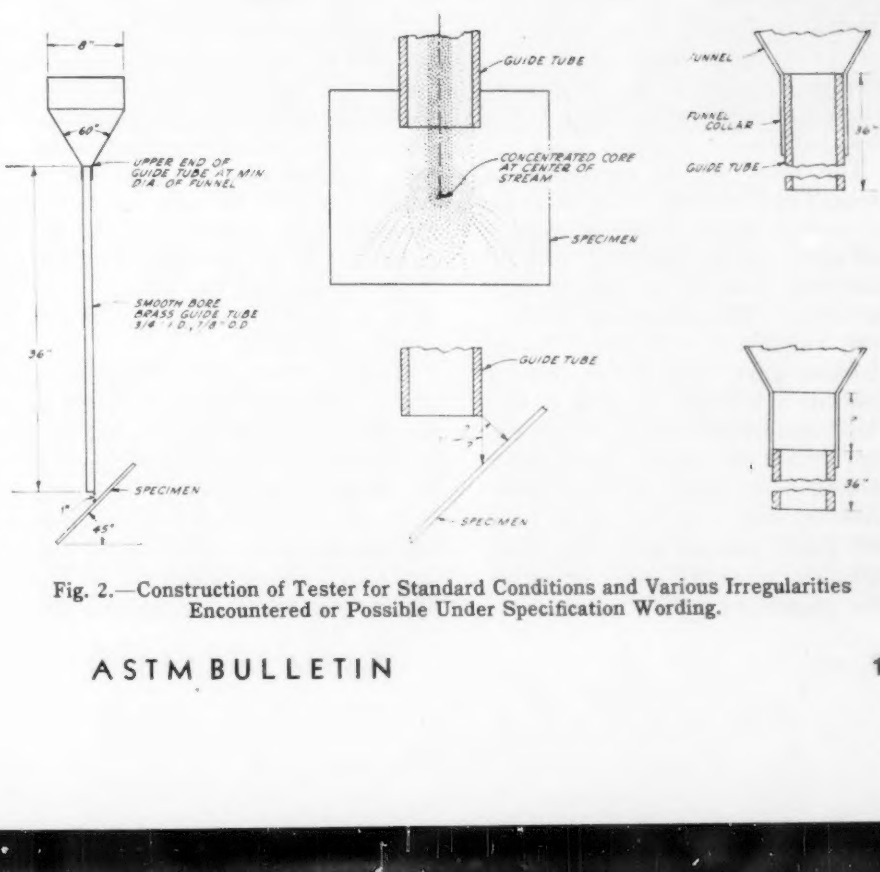

Fig. 2.—Construction of Tester for Standard Conditions and Various Irregularities Encountered or Possible Under Specification Wording.

As the flow rates increased, the abrasion resistance tended to increase, and since the rates were all practically within the specified limits of the AXS specification (5 liters of sand in 45 to 60 sec.) and the results varied by as much as 30 per cent, it appeared advisable to consider decreasing the rate of the flow limits.

Referring again to Fig. 1 and to the second horizontal line of specimens (group 2), it was evident that centralized wear spots were obtained but the abrasion-resistance values were much greater than those of group 1. Starting from the left, the first three participants' results were in the range 22 to 30 liters, while the fourth was much higher, namely, 48 to 60 liters. Examination revealed that the first two sets in the second group had larger over-all worn areas ($1\frac{3}{8}$-in. maximum width, $1\frac{3}{4}$-in. maximum length), and the lower concentration of sand particles per unit area resulting from this wider distribution would be expected to increase the abrasion values obtained. Apparently, the machines on which these results were obtained had guide tubes of larger inside diameter than the $\frac{3}{4}$ in. specified; the distance from the tube to the panel was greater than 1 in., or some structural detail was interfering with the free fall of the abrasive. In connection with the guide tube dimensions, it was ascertained that some laboratories assumed that a $\frac{3}{4}$-in. pipe size was required instead of a tube of $\frac{3}{4}$-in. inside diameter. The inside diameter of $\frac{3}{4}$-in. iron pipe size is approximately 0.81 in. and its use results in larger wear patterns.

The third set of specimens in group 2 had patterns which were intermediate in size between group 1 and sets 1 and 2 of group 2, with results that were in agreement with the latter. The laboratory in question employed a 0.81-in. inside diameter guide tube and reported a flow rate of 5 liters of sand in 40 sec. These factors combined to give the high values obtained. The smaller pattern may have resulted from closer spacing between guide tube and panel surface and also from variation in panel angle or guide tube alignment during testing, evidenced by the change in position of the worn area within the abraded pattern.

The fourth set of panels in group 2 exhibited wear patterns similar to the first two in this group, but the results were much higher. Investigation revealed that this instrument employed a shorter ($29\frac{1}{2}$ instead of 36 in. long) guide tube than that specified, and that the inside diameter was 0.81 in. To bring the flow rate within the specified limits, a sand control gate was maintained in a partially closed position. These three factors resulted in the large increase in abrasion resistance reported.

Group 3 contains those specimens which, as revealed in Fig. 1, third row, do not have the centralized wear spot as specified. The appearance of the abraded areas indicated that some of the machines had larger guide tubes than specified, that extraneous attachments (ascertained in one of these cases) resulted in deflection and nonuniform distribution of the sand particles, and that some of the panels were allowed to change position in relation to the column of falling sand during the testing.

In recapitulating the foregoing results, it becomes apparent that interlaboratory duplication was possible and had been achieved in group 1 of this test. Further, that in some instances in which divergencies in results occurred, it was possible to trace the abnormality to structural differences, or to nonstandard methods of procedure. Some of the structural details which were found to differ on different machines included: length and inside diameter of guide tube, rate of sand flow, incorporation of sand valves which disturbed the free fall of the abrasive, and alignment of the apparatus. It is probable that the other instruments on which variations in results were obtained had similar differences.

It seems advisable to emphasize at this point that the sand distribution has a decided effect on the end point obtained and is dependent on the proper alignment of the guide tube and on the absence of obstructions in the tube. The desired distribution, and one which can be obtained, consists of a concentration of particles in the center of the falling stream and a decrease in density as the tube wall is approached (see Fig. 2 (*b*)). In aligning the tube, the entire apparatus should be so leveled as to locate the inner more concentrated fall in the center of the falling stream, rather than by placing a level on the tube itself.

From the standpoint of precision it is highly undesirable to employ any device for controlling the sand flow which requires cutting through the tube wall and inserting gates or valves which project into or affect the inside tube diameter in any way. One instance was found in which a modified gate valve was employed. This arrangement resulted in three constrictions in the tube, thus shortening the free fall of the sand and disturbing the sand distribution. In other cases, a starting and stopping device consisting of a thin metal strip (approximately $\frac{1}{32}$ in. thick) fitted into a deburred slot cut in the tube wall has been advocated, but in view of the findings that any interruption distorts the sand pattern either by venturi action at the slot or by mechanical interference even this simple arrangement is not recommended. All such undesirable devices can be avoided by employing measured increments of sand which are poured into the funnel until the film under test is broken through.

In addition to the misinterpretation possible with regard to the tube size previously mentioned, there are other factors which have been misconstrued. The specification mentioned that "the distance from the tube to the panel at the nearest point is one inch," but did not state whether this distance was to be measured vertically from the lower edge of the guide tube to the panel, or normal to the panel surface (see Fig. 2 (*c*)). Both methods of positioning have been employed. Secondly, the method mentioned "a funnel which fits snugly over the outside of the tube" and which is employed as a sand reservoir at the upper end of the guide tube, but did not state how the upper opening of the guide tube was to be positioned in relation to the minimum funnel diameter. Conceivably cylindrical collars varying by several inches in length might be used for connecting the

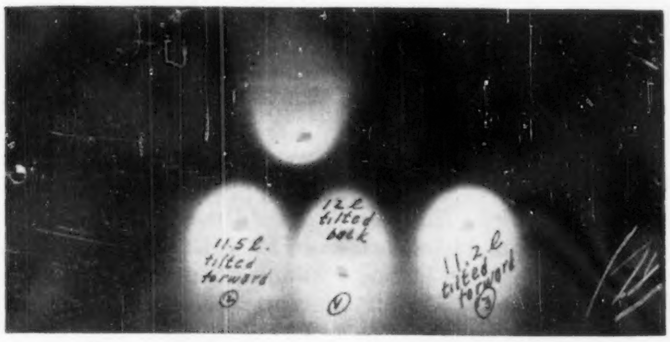

Fig. 3.—Extraneous Rupture at Top Due to Tilting.

funnel to the guide tube, thus in effect varying the length of free fall of the sand (see Fig. 2 (*d*)). Finally, neither the wall thickness of the tube nor the inside diameter of the funnel collar was mentioned and although few data are available to permit definite statements as to the effect of different wall thicknesses, it has been found that on one machine the sand flow rate was increased from 55 to 52 sec. for a 5-liter increment by increasing the outside diameter of the tube from $\frac{7}{8}$ to $1\frac{3}{8}$ in., maintaining the inside diameter at $\frac{3}{4}$ in. In addition, if the spacing of the guide tube from the panel was to be established at 1 in. at the nearest point, the distance would vary depending on the wall thickness of tubing used.

In regard to the end point itself, it was apparently the practice of several users of the machine to consider the test completed when break-through occurred at the top of the wear pattern. This method is not only at variance with the specified procedure but also results in wide divergencies in wear values. It has been found that break-through at the top is attributable to two causes. The first of these, and one which can be remedied, is poor alignment of the apparatus, as illustrated in Fig. 3. In running tests on this specimen the instrument was purposely tilted, and, as shown, it was possible to cause break-through at the top on a panel exactly similar to that on which a normal wear spot was obtained under good alignment conditions. (Compare Fig. 3 with the center panel top row, Fig. 1.) The second cause for crescent-shaped break-through at the top is very probably associated with low adhesional level of the particular finish being tested and will occur even if the machine is perfectly aligned in such cases. In an effort to substantiate this theory and to determine why break-through occurs in such a manner when the adhesional level is low, the panels shown in Fig. 4 were prepared and tested. The three panels were all given one coat of the same black lacquer. That on the left is a brass panel which was scratch-brushed prior to application of the lacquer, and as the material in question has fairly good adhesion on brass, it was possible to wear through at the center without better to illustrate the probable mechanism of such abnormal failure. The center panel shows initial lifting of the finish film due to adhesional failure, and that on the right, the first signs of rupturing of the lifted portion. The wrinkles formed in the film on lifting have been rapidly cut through by the sand particles. The failure does not occur at the center of the pattern under these conditions because, as previously mentioned, the falling sand is more concentrated in the center of the stream than at the outer edges when the tube is properly aligned. Therefore, under the impact of such a stream the film near the center is more frequently and more uniformly struck, and those stresses which probably develop within the film are equally distributed, or if inequalities occur, the frequency of impact prevents lifting. Near the edges, however, the blows are more scattered and infrequent and not only will unequal stresses probably develop in the film but the infrequency of impact permits lifting of

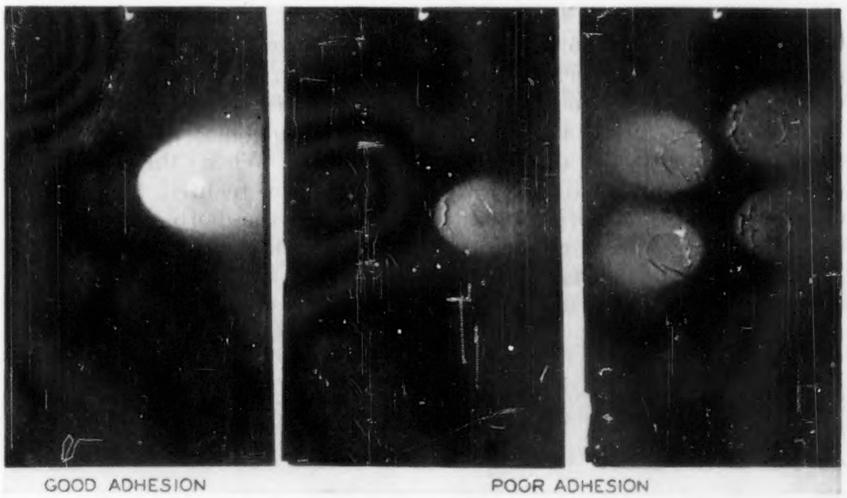

Fig. 4.—Effect of Adhesional Level on Type of Failure Obtained.

extraneous break-through, as illustrated. The other two panels shown were amalgamated with mercury prior to application of the lacquer and the adhesional level was therefore greatly reduced. Inspection will reveal that had the test been carried further, break-through would have occurred at the top on these runs. The sand flow, however, was purposely stopped at different periods prior to complete break-through in order the finish from the base. This condition is clearly illustrated in Fig. 4. This lifting does not occur all around the periphery of the abraded area because the panel is mounted at 45 deg. to the vertical and the upper edge of the wear pattern is closest to the guide tube. As the sand strikes the panel, it rebounds at an angle to the normal equal to that of the incident angle, resulting in an interfering stream at right angles to the downward fall of sand. It is only at the

top of the wear pattern that such interference does not exist and it is only here, therefore, that lifting and extraneous break-through will occur. At all other areas around the edge of the wear pattern, the cross stream interferes with the initial stream and prevents failure. At the center, of course, the concentration is such as to cut through the relatively smaller amount of sand particles traveling horizontally, and the wear spot will appear in the center of the abraded area under good conditions of adhesion.

Conclusions

On the basis of the available data and with consideration of the various factors discussed in the foregoing sections, it is felt that the falling sand abrasion tester can be standardized and uniform results obtained. This conclusion is based on the close agreement realized in several cases among various laboratories and on the probability that variations in the other cases resulted from structural differences in the apparatus. It will therefore be necessary to insure uniformity of construction of the critical elements of the abrasion instruments to obtain comparable results among various laboratories. To attain such an objective some sections of the test method should be reworded to minimize the possibility of misinterpretation, precautions regarding the importance of properly aligning the apparatus should be added, and the permissible variation in rate of sand flow should be narrower than heretofore. To this end the following is proposed.

Abrasion Resistance:

The apparatus used in this test should consist of a straight smooth bore metal tube 36 in. long, having an inside diameter of 0.750 ± 0.003 in. and an outside diameter of 0.875 in. The ends of the tube should be cut square and all burrs should be removed. This tube should be firmly supported in a vertical position over a suitable receptacle. The abrasive material, Ottawa sand (20 to 30 mesh), should be placed in a funnel which fits snugly over the outside of the tube. The funnel walls should converge continuously at a 60-deg. angle until the minimum inside diameter coincides with the outside diameter of the guide tube. The funnel may be continued from this point on as a cylindrical collar to fit over the outside of the guide tube. The upper end of the guide tube should coincide with the minimum diameter of the funnel at the area of the juncture of the cylindrical collar. After a diameter of 8 in. has been reached, the upper part of the funnel may be continued as a cylinder. When these conditions have been realized, the sand on reaching the bottom of the tube scatters to strike a surface on the specimen about one inch wide and one and a quarter inches long. The sand should be poured in, in reasonable increments, until the required amount has been used. These increments may be fairly large at the start of the test, but should be decreased as the end point is approached. Five liters of sand should flow through the apparatus in 52 to 59 sec. The area of maximum abrasion should occur on the center line through the longer axis of the abraded pattern and within $\frac{9}{16}$ to $\frac{11}{16}$ in. from the top edge. A worn spot $\frac{5}{32}$ in. in diameter should be considered as the abrasion end point. Centering of the wear spot should be realized by so aligning the machine as to cause the concentrated inner core of the sand stream to fall in the center of the flow when viewed from two positions at 90 deg. to each other. The coated panel should be fastened at an angle of 45 deg. to the vertical in such a position that the opening of the tube is directly above the area to be abraded and the distance from the tube to the panel at the nearest point is 1 in. when measured in a vertical direction parallel to the axis of the guide tube. The coating thickness should be measured at two positions as close as possible to the abraded area and the abrasion resistance given in terms of liters of sand per mil (0.001 in.) thickness of coating.

NOTE.—The above procedure makes no provision for a control to start and stop the sand flow, as in the proposed method there is no need for such a device.

A New Sandpaper Abrasion Tester

By F. M. Gavan,[1] S. W. Eby, Jr.,[1] and C. C. Schrader[1]

SYNOPSIS

This paper describes an abrasion machine employing a continuously changing abrasive surface. It has been in use since 1941 in testing various flooring materials, synthetic resins, substitute rubber compounds, metals, and painted surfaces.

Essentially, the machine consists of two independent units: (1) a vertical track which carries the specially prepared specimens around to meet the abrasive, and (2) a carriage which rests on roller bearings and has provision for keeping a strip of sandpaper in continuous motion while abrading the samples. The directions of motion of the sandpaper and samples are opposite, and contact between the two is maintained by dead weights attached to the carriage by a cable-spring-pulley arrangement.

Standard comparison specimens of zinc are tested with each run. Measurements taken on these standards over a period of years have shown the sandpaper to be reasonably consistent.

Although complete refinement of technique for some materials has not yet been achieved, this paper is presented now because it is felt that this approach to an old problem holds great promise and should be of immediate interest to those confronted with the manifold problems of wear-resistance measurement.

THE technique of obtaining a quantitative measure of the resistance of a material to the effects of routine wear has been a matter for much discussion during the past 25 to 30 years. The fabric, rubber, structural stone, paint, plastics, and flooring industries have been the chief contributors from the standpoint of design of testing equipment, and each has, in ways peculiar to its own problems, attempted to correlate the results of laboratory measurements with service evaluation. However, no wear test machine has gained widespread acceptance, even within the industry fostering its design, and there is some question of significance of results and reproducibility about most of those in use (**20, 25, 26, 27**).[2] This is reflected in a general reluctance on the part of manufacturers, purchasers, and independent testing organizations to incorporate wear tests in their specifications, even when wear resistance is the prime consideration.

A rather extensive survey of the literature revealed that a great factor contributing to this confusion about wear resistance is the lack of concerted thinking on the precise definition of wear. *Wear*, to the rubber tire manufacturer, is a property altogether different from *wear* as conceived by the manufacturer of broadcloth shirts. It follows from this that, since the conditions under which wear takes place vary so greatly from one use to another, the word denotes nothing more than "loss of serviceability."

It is probably true, however, that the one variable most common to all service conditions of wear is that of abrasion. As used here, *abrasion* is taken to mean a gradual tearing away of the surface of a material by the action of relatively fine, hard particles; it is a frictional manifestation which involves all of the fundamental stresses, and it does not lend itself to the ordinary methods of stress analysis. One of the chief aims in the design of this machine has been to divorce the measurement of abrasion from the complicating factors (such as impact, extreme temperatures, chemical action of liquids, etc.) which are often encountered in service but which usually tend to confuse, rather than amplify, a test evaluation. Each individual service use is a problem in itself, and any attempt to evaluate a product by an arbitrary combination of all the complexities involved in the service restricts the practical value of the measurement unnecessarily. The best that can be hoped for is a reliable, comparative evaluation of products with respect to each of the components contributing to the total effect; here, abrasion has been selected as one of the components. Hence, the instrument described is an abrader which measures simply the abrasion resistance of various materials under standardized conditions. At this point in the development of the tester, the only recognized use of the information obtained is for comparing the sandpaper abrasion resistance of various products or formulations of the same product with each other—not for comparing the relative suitability of these products for any general service. Further research will, of course, broaden the significance of the test data and permit some correlation with specific types of wear.

PRELIMINARY CONSIDERATIONS

There are certain specifications necessary to produce a good abrasion test; for purposes of design the following points were deemed essential:

1. The abrasive (size, shape, hardness, concentration) should be similar to that encountered in service.
2. Slippage between the abrasive and the specimen should take place at a speed comparable with that encountered in service.
3. Pressure applied to the specimen during abrasion should be constant and should not be excessive.
4. Excessive heat should not be developed in abrading the specimen. Intermittent abrasion is probably the best method of assuring this.
5. The sample and abrasive should be kept dry and, most important, free from contamination.
6. The action of the abrasive should be constant throughout the duration of the test.

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[2] The boldface numbers in parentheses refer to the references appended to this paper.

7. Some standard for measuring the integrated effect of the abrasive should be employed in each test or run.

8. An accurate and positive means of determining a quantitative measure of the resistance of the sample to abrasion should be possible.

Types of Abrasion Testers

The principles involved in various abrasion testers can be classified as follows:

1. Loose abrasive (sand, carborundum), dropped or blown onto the surface of the specimen (**5, 10, 15, 18**).
2. Samples whirled in a loose abrasive (sand, carborundum) (**3**).
3. Specimens mounted on the inside periphery of a revolving drum containing loose abrasive (sand) or steel slugs.
4. Samples rumbled inside a revolving drum with no abrasive; a pure impact, wearing action.
5. Stationary or moving specimens held against the edge or side of a turning abrasive wheel; the most common type. (**2, 4, 7, 8, 11, 12, 13, 14, 16, 20, 21, 23, 24**).
6. Moving abrasive block attached to a Pitman rod and pulled back and forth over the surface of a sample; or the reverse, with the specimen mounted on the moving arm and pulled across the abrasive surface (**9, 17, 22**).
7. Sample scratched or indented by a hard instrument pulled over or dropped on its surface (**6, 19**).

Modifications of these ideas include the use of impact, flexure, reverse motion of sample or abrasive, liquids, etc., to supplement the action of the abrasive.

Previous Testers:

There is one fault common to practically all of the above techniques: in all cases contamination of abrasive and sample occurs during tests. Unless there is some provision for constantly changing the abrasive, it is evident that the nature of the abrading surface will be changed during the test, thus destroying the constancy of abrasion given the samples. With semiplastic or oleoresinous compositions, this "clogging" of the abrasive is sometimes so pronounced that the abrasive is rendered impotent after one or two passes over the sample; relatively hard or rough compositions have a natural tendency to pull the abrasive particles from the carrier, thereby changing its character.

The instrument under discussion is based on the principle that a continuously moving sandpaper tape constantly presents a fresh abrasive surface to the firmly held but oppositely moving specimen. The moving sandpaper idea cannot be claimed as entirely original; during a study of the literature in preparation for this report, the authors discovered an article (**1**) describing an instrument making use of a similar principle, with adaptations for testing fabrics.

Present Tester:

The instrument described in this paper is believed to have the following advantages over the other known types:

1. *Moving abrasive.*
2. *Range of application.*—A versatile abrasive-weight-sample size arrangement permits the testing of almost any rigid or semirigid composition; the more flexible or soft materials present some difficulties, but in most cases they can be overcome by a slight deviation from standard procedure.
3. *Cost of operation.*—Disregarding the original cost and the maintenance costs of the machine, the expense involved in making routine tests is very low. For a group of eight samples, the cost of the abrasive is approximately five cents; time spent by a laboratory assistant in preparing the specimens, making necessary measurements, and supervising the test for these eight samples amounts to approximately two hours.
4. *Relative value of results.*—By means of the comparison standard, an abrasion loss obtained on one sample can be used for direct comparison with losses obtained on samples within the same run or in any other run.
5. *Accuracy of duplication of results.*—Data obtained to date have indicated that the losses on duplicate samples of homogeneous materials (tested in one or different runs) will deviate less than 5 per cent from the average.
6. *Heat dissipation.*—The abrasive action on the sample is intermittent, with approximately 36 sec. elapsing between consecutive passes of the sandpaper. This allows sufficient time for dissipation of the heat developed during abrasion, as well as for elastic relaxation.
7. *Directional abrasion.*—Since the relative motion of sandpaper and sample is in one direction only, it is possible, by proper positioning of the sample on the machine, to test anisotropic compositions for directional effect on abrasion.
8. *Alternate and intermittent periods of abrasion.*—Samples can be removed from the machine at any point in the test for measurement or treatment and can be replaced any time afterward for further abrasion. By determining abrasion loss on samples at convenient time intervals, the abrasive resistance through the thickness of a material can be measured. A test with alternating cycles of abrasion and treatment (aging, immersion in liquids, etc.) reveals valuable information. The ability of this machine to give constant abrasion at any time makes many studies of this type possible; it has been used, for instance, to determine the effect of immersion in oil on numerous products.
9. *Adjustable speed of sandpaper and samples.*—If special studies make it desirable, greater speeds of sandpaper or samples can be obtained.

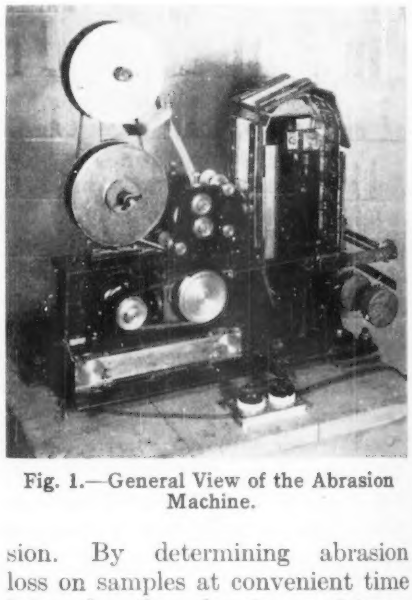

Fig. 1.—General View of the Abrasion Machine.

Description of Machine

Figure 1 gives a general view of the tester, while the mechanics of the machine are shown schematically in Fig. 2. A specimen under test is clamped to one of the eight conveyor plates P connected to an endless roller chain which travels around two pulleys Q, the lower of which is driven by a reduced, $\frac{1}{4}$-hp., electric motor (not shown). The conveyor plates move vertically downward at point of contact with the sandpaper and at a surface speed of 80 in. per minute. These plates pass through a keyway at the front end, which keeps them in a vertical plane and prevents movement in any direction while the sample is being abraded; they are made of 0.3-in. thick corrosion-resistant steel and are quite rigid in themselves.

The carriage H contains the sandpaper and mechanism for moving the sandpaper. This carriage rests on roller bearings L and during the test is free to move forward under the force of a weight W which is connected to the carriage on each side by a spring cable M over a pulley N. The sandpaper ribbon, 2 in. wide, is unrolled from the bottom reel G by passing it through two rubber-covered pressure rolls B which are driven by a $\frac{1}{8}$-hp. electric motor (not shown) through a gear reducer (not shown); a clutch arrangement on reel G keeps the sandpaper taut while passing over slotted guide rolls F and E, over a 2-in. diameter steel contact roll D, and over slotted guide roll C. Reel A is provided with a means for rerolling the sandpaper.

The sandpaper moves in a direction opposite to that of the conveyor plates at a surface speed of 20 in. per minute, thus bringing the differential speed between sample and sandpaper to 100 in. per minute. This speed is not sufficient to produce an appreciable amount of heat in any material tested.

It can be seen that as a thicker sample (one protruding more from the conveyor plates than the preceding one) meets the contact roll D, the carriage is moved back to accommodate it. The spring R has an important function when this happens. It was found that the carriage, when directly connected to the weights by a wire cable, had to overcome the inertia of the weights in moving to a thicker sample; this force was translated into additional abrasion loss on this sample. The difficulty was overcome by replacing a portion of the wire with a tension spring. A slight movement in the carriage in allowing for a thicker specimen is taken up by the spring; the force required to do this is imperceptible and does not affect the amount of abrasion given the thicker sample.

Particles removed from the sample and sandpaper in the process of abrasion are carried off by the sandpaper, and there is no contamination of either sample or incoming sandpaper. The sandpaper is discarded after being used once. If very soft materials such as textiles, are tested, it will be advisable to provide a cleaning device.

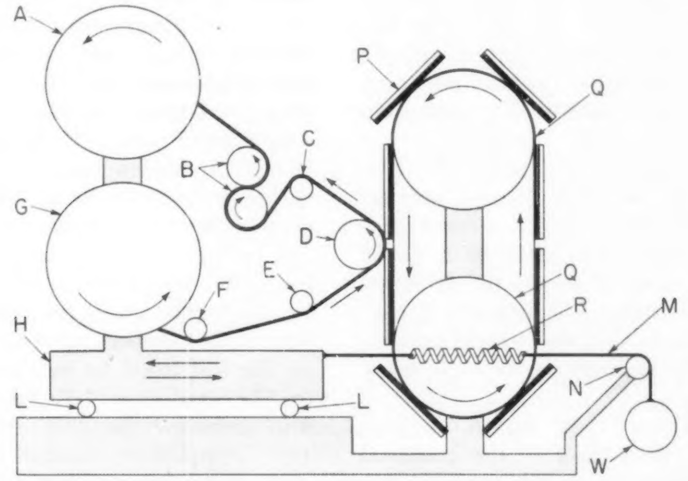

Fig. 2.—Schematic Drawing of the Abrader.

A close-up view of a specimen clamped to a conveyor plate and ready for test is shown in Fig. 3.

Figure 4 gives the sample size and assembly. The sample A, measuring $4\frac{1}{2}$ by $1\frac{3}{4}$ in. ($\pm$0.01 in.), is cemented onto the surface of a sample plate B. The sample plate is made of $^1/_{32}$-in. thick aluminum and is designed to give a rigid cementing surface of minimum weight. After the adhesive has been allowed to dry sufficiently (usually 24 hr. at 70 F. and 55 per cent relative humidity), the sample and plate are weighed on a balance accurate to 0.01 g. Shims, or bumper strips, which have been cut from material adjacent to the sample, are placed in position at each end of the sample, and the whole assembly is clamped (at points marked x) onto the conveyor plate. The shims measure 5 by $\frac{3}{4}$ in. ($\pm$0.01 in.), and their purpose is to lead the sandpaper-contact roll on and off the sample without harming its edges. Since the abrasion of these shims has no effect upon the measured weight loss, the abrasion loss due to chipping or bumping in going from one specimen to another is eliminated.

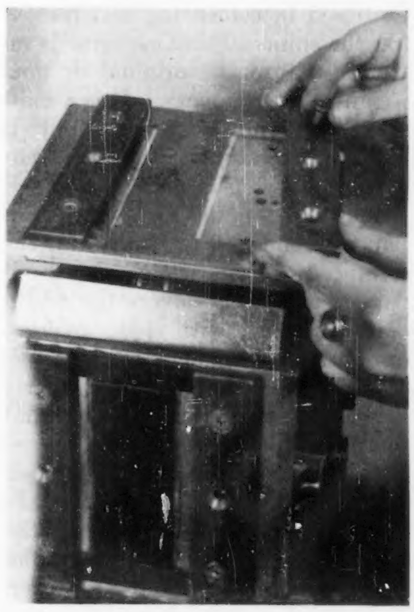

Fig. 3.—Test Specimen, Cemented to Aluminum Sample Plate, Being Clamped to Conveyor Plate. Shims have been laid in place at both ends of the sample.

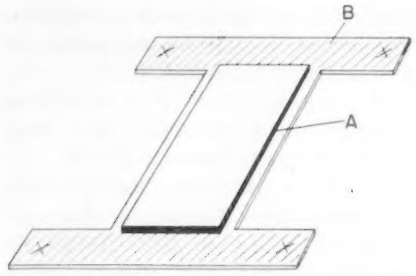

Fig. 4.—Abrasion Sample Mounted on Aluminum Sample Plate.

After the sample has been abraded, the sample plate and sample are reweighed, and the weight loss determined. (The treatment of the data obtained is discussed later in this paper.)

In the case of thin, highly flexible materials (rubber tread stock) it is sometimes necessary to cement the shims to the sample plate in order to keep them from tearing or pulling out from under the clamps. Here, the procedure is the same as above except that care must be exercised in cementing and removing the shims so that no error is introduced into the original or final weight measurements. It is a matter of careful technique, but is neither exceedingly difficult nor overly time-consuming.

It will be noted that the sandpaper ribbon is 2 in. wide, and the sample is $1\frac{3}{4}$ in. wide; the sandpaper completely covers the width of the sample, with $\frac{1}{8}$-in. overlap on both sides. This is done because it was found in the early development of the machine that sample preparation could not consist merely of clamping a specimen of the composition to be tested onto the conveyor plate and allowing the sandpaper to abrade a path from one end of the sample to the other. Two errors are introduced when this method is used: (1) excessive wear occurs at the edges of the thicker specimens, and (2) the sandpaper has a tendency to "ride" the edges of the groove it has abraded, causing an inconsistent abrasive action.

The four adjustable functions of this instrument are itemized below:

1. *Abrasive medium.*—Practically any thin substance available in rolls of 2-in. ribbon could be used as the abrasive. Heavy canvas, emery cloth, and sandpaper of various grits have been tried with success; 0E grade sandpaper supplied by Behr-Manning Division of Norton Co., Troy, N. Y., has been adopted as standard for most materials.

2. *Size of sample.*—Although practice dictates a maximum $4\frac{1}{2}$ by $1\frac{3}{4}$-in. specimen, the length could be decreased to approximately 2 in. and the width to $\frac{1}{2}$ in. with no serious difficulty. The maximum thickness which can be handled conveniently is $\frac{1}{2}$ in.

3. *Weight.*—Any weight from 5 to 50 lb. can be used. It should be noted that these weights are the total load on the sample. The fact that they exert their force on the sample through a cylinder (the contact roll) makes it impossible to calculate exactly the pressure (in pounds per square inch) involved. A rough estimate of the average pressure on a medium hard material when the standard 30-lb. weight is used would be 30 to 60 psi. However, the important consideration—that the weight be constant throughout the test—is satisfied.

4. *Time.*—Any length of time can be used, and if the material under test is homogeneous, abrasion loss is directly proportional to time. This proportion arises from the fact that the abrasive action is always constant, and it is of value when a study of the abrasive resistance at various points through the thickness of a nonhomogeneous sample is desired. The sample can be removed from the machine at various time intervals for weighing. The standard running time has been set at 40 min. for materials tested in this laboratory.

Comparison Standard

In order to make a direct comparison between samples tested in one run and those of another run some means of checking the constancy of the abrasive must be employed in each run. This is accomplished in this tester by abrading two calibrated zinc specimens with each run. The zinc[3] was purchased especially for this purpose and, by its very nature, embodies these necessary properties:

1. Abrasion resistance measurable in the range of most commonly tested materials, such as hard surface floorings.
2. Essential freedom from aging and work-hardening effects.
3. Homogeneity within a group and within a sample. (The same specimen is used many times before discarding it.)

The original purpose of these calibration specimens was to recalculate losses obtained on all of the samples in one run relative to the loss obtained on the comparison standards tested in that run, thereby making all data obtained on this machine directly comparable. It has been found, however, that the sandpaper is so consistent that this is unnecessary and, in fact, inadvisable, because in those few cases in which the comparison standards have not shown the expected amount of loss, the operator's technique has been found to be at fault. Very conveniently, the use of the comparison standards has developed as a check on the test itself, as well as a check on the sandpaper. Present procedure calls for the abrasion of two zinc comparison specimens with each group of samples, and if the weight losses of both do not fall within the specified limits, all results are immediately under question. Usually, the technique used is reviewed, and a retest made.

By representative sampling and

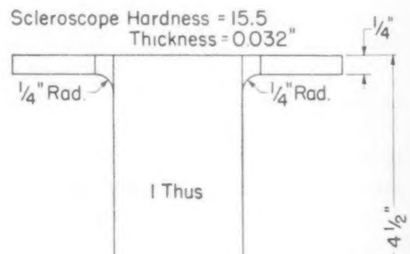

Fig. 5.—Zinc Calibration Specimen.

[3] Obtained from New Jersey Zinc Co. (of Pa.), Palmerton, Pa.

TABLE I.—ABRASION LOSSES ON A GROUP OF EIGHT ZINC COMPARISON STANDARDS TESTED IN EIGHT DIFFERENT RUNS.

Condition of Test: 0 Grade sandpaper, 30-lb. weight, 40-min. running time for each run.

Conveyor Plate	Loss for Run Stated, g.								Plate Average
	1	2	3	4	5	6	7	8	
No. 1......	0.53	0.53	0.52	0.52	0.51	0.53	0.54	0.52	0.53
No. 2......	0.52	0.55	0.52	0.52	0.52	0.53	0.55	0.52	0.53
No. 3......	0.51	0.54	0.51	0.53	0.53	0.52	0.54	0.50	0.52
No. 4......	0.51	0.54	0.53	0.53	0.52	0.53	0.54	0.51	0.53
No. 5......	0.51	0.54	0.52	0.52	0.52	0.52	0.54	0.51	0.52
No. 6......	0.52	0.53	0.52	0.53	0.52	0.53	0.54	0.53	0.53
No. 7......	0.52	0.54	0.52	0.52	0.53	0.53	0.55	0.52	0.53
No. 8......	0.51	0.54	0.54	0.52	0.53	0.53	0.55	0.52	0.53
Run Average..	0.52	0.54	0.52	0.52	0.52	0.53	0.54	0.52	

application of statistical methods, the standard loss value for these zinc comparison standards was set at 0.50 to 0.55 g. for standard conditions (0E sandpaper, 30-lb. weight, 40-min. running time).

A new comparison standard specimen is always calibrated with several older ones before it is put into routine use. The average life of a specimen is about twenty standard tests, and it is of standard dimensions but of slightly different design (see Fig. 5).

Treatment of Data and Typical Results

There are a number of ways to express abrasion resistance, some of which attempt to put the value on an absolute basis. The two most commonly accepted expressions (loss in thickness and loss in volume) are used here since they give a measurement of the visible damage done by the abrasion.

Loss in thickness is obtained by gaging the specimen at several points with a dial micrometer before and after abrasion, the difference being the loss.

Volume loss has been found to be a more dependable means of measuring the same effect and is obtained by dividing the weight loss of the sample in grams by the density (grams per cubic centimeter) of that particular sample, thereby giving loss in cubic centimeters.

Although weight loss has no value for comparison purposes, all losses on the comparison standards are reported in grams. These figures serve as a running check and are not used for comparisons.

A calculation device often employed to obtain a better average thickness loss is the division of the volume loss by the abraded area of the specimen to give thickness loss.

In addition to the quantitative observations, a visual examination of the abraded samples often reveals useful information for practical evaluation; tendencies to tear readily or "pit" at the surface are encountered occasionally.

Table I shows losses on a group of eight zinc specimens tested under

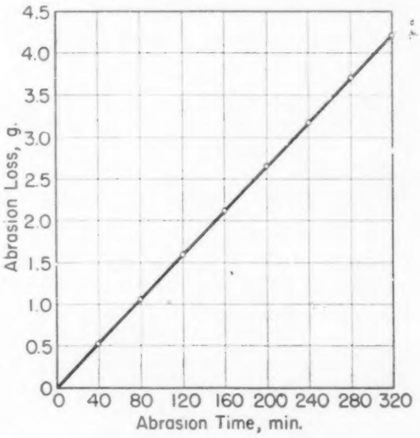

Fig. 6.—Zinc Comparison Standard, Relation Between Abrasion Loss and Abrasion Time.

standard conditions in eight different runs, a different roll of sandpaper being used for each run. Conclusions to be drawn are as follows:

1. The zinc and sandpaper are reasonably consistent.

2. The relation between abrasion loss and abrasion time is a direct proportion (see Fig. 6).

3. The abrasive action is constant.

These observations have been substantiated by other tests made on various types of materials.

Table II gives abrasion losses on zinc comparison standards when different conditions of weight and grade of sandpaper are used. All tests were run for 40 min. The following comments can be made:

1. There seems to be good agreement between losses on individual samples using various grades of sandpaper (00, 0, $\frac{1}{2}$, and 1, in order of increasing coarseness).

2. The abrasion loss is essentially proportional to the applied weight within the practical range (see Fig. 7). It might be surmised from this that, other conditions being equal, as the width of a sample decreases the abrasion loss remains at a constant value because of the corresponding increase in pressure on the sample; as a matter of fact, this has been found to be true in the case of some homogeneous compositions, but it has not been tried on a sufficient number of materials to be regarded as universally applicable. This fact also proves useful in determining weights to be used on an unfamiliar composition.

Table III shows typical abrasion results on six different materials (six different runs); two comparison standard specimens were tested with each run of six duplicate samples. Standard test conditions were used, and it will be noted that the comparison standard losses are given in grams, and all other losses in cubic centimeters. The materials used included rubber, plastics, and oleoresinous compositions.

To prove the point that any sample receives essentially the same amount of abrasion, regardless of

TABLE II.—ABRASION LOSSES ON EIGHT ZINC COMPARISON STANDARDS WHEN VARYING CONDITIONS OF WEIGHT AND GRADE OF SANDPAPER ARE USED.

Condition of Test: 40-min. running time for each run.

	Loss for Conditions Given, g.[a]						
Grade of sandpaper....	0	0	0	0	00	$\frac{1}{2}$	1
Weight used, lb.......	10	20	40	50	30	30	30
Conveyor Plate:							
No. 1..............	0.20	0.35	0.67	0.83	0.46	0.64	0.68
No. 2..............	0.22	0.36	0.68	0.88	0.46	0.65	0.67
No. 3..............	0.22	0.37	0.66	0.87	0.46	0.64	0.69
No. 4..............	0.21	0.39	0.66	0.86	0.46	0.64	0.69
No. 5..............	0.21	0.38	0.65	0.84	0.47	0.64	0.69
No. 6..............	0.22	0.35	0.66	0.83	0.46	0.65	0.69
No. 7..............	0.21	0.35	0.66	0.85	0.46	0.64	0.68
No. 8..............	0.22	0.37	0.66	0.84	0.46	0.66	0.68
Average............	0.21	0.37	0.66	0.85	0.46	0.65	0.69

[a] See Table I for data obtained with 30 lb. and 0 grade sandpaper.

TABLE III.—TYPICAL ABRASION LOSSES ON A GROUP OF SIX REPRESENTATIVE MATERIALS.

Conditions of Test: 0 grade sandpaper, 30-lb. weight, 40-min. running time.

Material	A	B	C	D	E	F
Density of material, g. per cu. cm.	1.86	1.36	1.38	1.83	1.92	1.38
Comparison Sample Loss, g.						
Conveyor Plate:						
No. 1 (zinc A)	0.53	0.55	0.50	0.51	0.53	0.53
No. 2 (zinc B)	0.52	0.52	0.52	0.53	0.51	0.52
Loss, cu. cm.						
No. 3	1.56	1.20	1.83	1.08	0.83	1.72
No. 4	1.55	1.18	1.85	1.11	0.86	1.70
No. 5	1.57	1.18	1.77	1.15	0.86	1.71
No. 6	1.55	1.17	1.81	1.13	0.87	1.73
No. 7	1.55	1.18	1.80	1.15	0.86	1.70
No. 8	1.55	1.19	1.88	1.13	0.83	1.68
Average loss (material)	1.56	1.18	1.83	1.13	0.85	1.71

its particular run or its position on the machine, the following tests, results of which are shown in Table IV, were devised:

In test No. 1, the same materials used for data contained in Table III were used; all materials were tested together in one run, and an attempt was made, in arranging the samples on the conveyor belt, to place the abrasive contaminating compositions, such as D, next to soft materials C. Test No. 2 is identical with test No. 1., except that the positions of the samples on the machine have been rearranged. Both tests were standard, and two comparison standards were tested in each run.

The results of the two tests in Table IV indicate that, regardless of the position on the machine and regardless of the run, every sample receives substantially the same amount of abrasion.

Test No. 3 in Table V shows rather conclusively that the moving sandpaper principle is the chief contributor to the constancy of abrasion attained in this abrader. This test is identical with tests Nos. 1 and 2, except that the sandpaper was not continuously moved during the test; it was necessary, however, to stop the test and shift the sandpaper to a new position every 3 min. Not only are the average losses in this test different from those in tests Nos. 1 and 2, but the the relative order of merit of the compositions is rearranged. These inconsistencies are caused by a contaminated and "spent" abrasive.

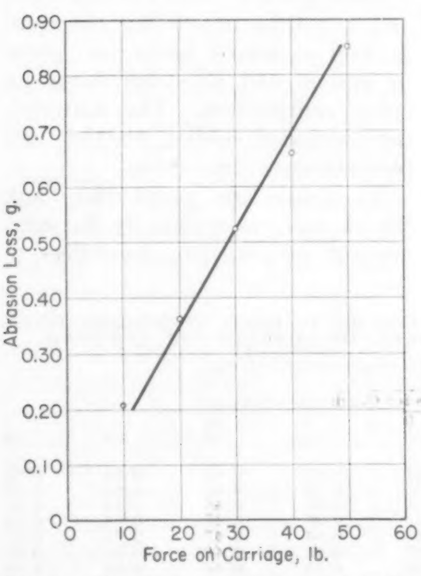

Fig. 7.—Zinc Comparison Standard, Relation Between Abrasion Loss and Force on Carriage.

TABLE IV.—TYPICAL ABRASION LOSSES ON A GROUP OF SIX REPRESENTATIVE MATERIALS WHEN THEIR POSITIONS ON THE MACHINE ARE REARRANGED.

Conditions of Test: 0 grade sandpaper, 30-lb. weight, 40-min. running time.

Test No. 1.—The same products tested for data in Table III were all tested in one single run.
Test No. 2.—All conditions were the same as in Test No. 1, except that the samples were rearranged on the conveyor plates.

Conveyor Plate	Test No. 1		Test No. 2		Average Losses		
	Material	Abrasion Loss	Material	Abrasion Loss	Material	Tests Nos. 1 and 2	Table III
No. 1	Zinc A	0.55 g.	D	1.29 cu. cm.	Zinc A	0.53 g.	0.53 g.
No. 2	Zinc B	0.55 g.	C	1.93 cu. cm.	Zinc B	0.55 g.	0.52 g.
No. 3	A	1.52 cu. cm.	A	1.52 cu. cm.	A	1.52 cu. cm.	1.56 cu. cm.
No. 4	B	1.09 cu. cm.	F	1.70 cu. cm.	B	1.11 cu. cm.	1.18 cu. cm.
No. 5	C	1.90 cu. cm.	Zinc A	0.50 g.	C	1.92 cu. cm.	1.83 cu. cm.
No. 6	D	1.25 cu. cm.	E	0.94 cu. cm.	D	1.27 cu. cm.	1.13 cu. cm.
No. 7	E	0.95 cu. cm.	Zinc B	0.54 g.	E	0.95 cu. cm.[a]	0.85 cu. cm.[a]
No. 8	F	1.70 cu. cm.	B	1.12 cu. cm.	F	1.70 cu. cm.	1.71 cu. cm.

[a] The discrepancy indicated here was undoubtedly caused by variation between different laboratory formulations of this material; the use of two samples in this case could not be avoided.

Future Development Plans

Some mechanical changes proposed to improve the operation of this abrader consist of a more positive, direct-drive method of rewinding the sandpaper ribbon after it has passed through the machine; an arrangement to stop the machine automatically when the test is completed; a clutch on the conveyor plate drive to enable the operator to move the plate system by hand; provision for measuring directly the force exerted on the carriage by the weights; a self-aligning contact roll with a rubber-covered surface which would automatically compensate for samples thicker on one side than on the other; a sample cleaning device (vacuum and brush). Also, there are a number of designs being considered to improve the sample holding devices now being used.

Several projects are planned to study the effect of other variables, such as high and low temperatures, liquids, etc., on abrasion; certain of these can be accomplished with very little or no redesigning.

A correlation between this machine and others in use in the industry will be attempted sometime in the future.

The relation between evaluation by test and certain service criteria is being studied at the present. There are some service applications in which abrasion similar to the rubbing action of sandpaper is the only practical consideration, and it is hoped that projection of test information into problems such as these may disclose something of the fundamental nature of abrasive

TABLE V.—TYPICAL ABRASION LOSSES ON A GROUP OF SIX REPRESENTATIVE MATERIALS WHEN THE SANDPAPER IS NOT CONTINUOUSLY CHANGED.

Condition of Test: 0 grade sandpaper, 30-lb. weight, 40-min. running time.

Test No. 3.—All conditions were the same as in Test No. 1, except that the sandpaper, instead of being continuously moved, was shifted to a new position every 3 min.

Conveyor Plate	Test No. 3		Test No. 1
	Material	Abrasion Loss	Abrasion Loss
No. 1	Zinc A	0.02 g.	0.55 g.
No. 2	Zinc B	0.02 g.	0.55 g.
No. 3	A	0.13 cu. cm.	1.52 cu. cm.
No. 4	B	0.07 cu. cm.	1.09 cu. cm.
No. 5	C	0.15 cu. cm.	1.90 cu. cm.
No. 6	D	0.10 cu. cm.	1.25 cu. cm.
No. 7	E	0.03 cu. cm.	0.95 cu. cm.
No. 8	F	0.04 cu. cm.	1.70 cu. cm.

forces and their effect on material surfaces.

Acknowledgment:

The authors wish to thank H. A. Robinson and C. N. Wenrich, under whose helpful direction much of this work was done.

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Toxicity of Germicides

Dr. Louis C. Barail, M.D., United States Testing Co., has carried out extensive work on evaluating germicides for fabrics. One such paper which he presented at the meeting of A.S.T.M. Committee D-13 on Textile Materials was published in the October, 1945, Bulletin covering a suggested method for thorough testing of antiseptic fabrics. Subsequently at a meeting of the New York Branch of the Society of American Bacteriologists, he presented a supplementary paper entitled "Toxicity of Germicides."[1] Since a number of those interested in the earlier paper would naturally be concerned with the later discussion, a few notes on it appear below. Dr. Barail has also just presented another paper on "Testing of Fungicidal Materials Against Pathogenic Fungi."

[1] Louis C. Barail, "Toxicity of Germicides," *American Dyestuff Reporter*, November 4, 1946.

The author has tested over 250 germicides for their performance on fabrics. The purpose of the tests was to find a germicide which would render light fabrics to be worn next to the skin, chemically sterile, germicidal, and fungicidal after a great number of washings.

All compounds were previously studied for toxicity, presence of skin irritants, and cutaneous sensitizers.

First, toxicity tests and minimum lethal dose determinations were made on the compounds. Then intradermal animal injections and patch tests on human skin were conducted for the presence of skin irritants and cutaneous sensitizers. The patch test method used was that recommended by Drs. Louis Schwartz and Samuel Peck of the U. S. Public Health Service. It consists in applying a patch on a minimum of 200 individuals for five days, observing the skin after removal and the following two days, and applying a similar patch for 48 hr. 10 days after removal of the first one.

Out of 250 compounds, only seven were acceptable because of their low toxicity, and among these, five were eliminated as skin irritants and cutaneous sensitizers. One compound which is not a skin irritant was found to be a cutaneous sensitizer. Only one is neither a skin irritant nor a cutaneous sensitizer even at concentrations higher than the normal concentrations of use.

The patch test method of Drs. Schwartz and Peck permitted the fact to be definitely established that of all compounds tested, the only satisfactory one for lack of toxicity is a long chain mercurial compound, whose formula is lactoxyphenylmercuric ammonium lactate and which renders light fabrics germicidal after as many as forty washings.

A Method for Predicting Failure of Metals*

By P. E. Cavanagh[1]

SYNOPSIS

This paper presents a discussion of the possibilities of using changes in high-frequency magnetic and eddy-current losses to predict failure in metals.

The method of recording changes in total magnetic and eddy-current losses (or "core losses") is described and examples of stress - core loss curves obtained are given.

Proof of the fact that this method will detect the beginning of plastic deformation due to overloading or fatigue leads to a practical application in the inspection of mine-hoist cable.

In a previous paper (**1**),[2] the author has described the use of high-frequency magnetic and eddy-current losses to compare stresses in metals. Various practical applications of this principle were discussed. One of the most interesting possibilities raised was the prediction of fatigue failure before it occurred.

In order for any type of failure to occur in metal some permanent distortion of the crystal lattice must take place beforehand. This distortion will change the magnetic and electrical properties and is detectable with sufficiently sensitive instruments (**2**, **3**). The Du Mont Cyclograph has been found to be a satisfactory tool in this connection, having stability, sufficient sensitivity, and great flexibility in the choice of test frequencies (**4**).

The auxiliary equipment used in the present investigation is shown in Fig. 1. The Cyclograph test coil was placed around the sample in the tension testing machine. The change in Cyclograph output (that is, total magnetic and eddy-current losses or core losses) was recorded on an Esterline-Angus meter. The meter recorder paper could be driven at a rate proportional to stress by the means shown in Fig. 2, or proportional to strain by suitable connections to the moving head of the tension testing machine.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Forty-Ninth Annual Meeting, Am. Soc. Testing Mats., Buffalo, N. Y., June 24–28, 1946.

[1] Research Fellow, Ontario Research Foundation; and Consulting Metallurgist, Allen B. Du Mont Laboratories, Inc., Passaic, N. J.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

Some typical stress - core loss or stress - Cyclograph curves for ferrous and non-ferrous metals obtained by the above method are compared with stress-strain curves in Fig. 3. Note should be made of the changes in slope of the stress-core loss curves at points well below those at which clear changes from linearity occurred in the stress-strain diagrams. The changes in slope are probably related to the limits of proportionality of the ma-

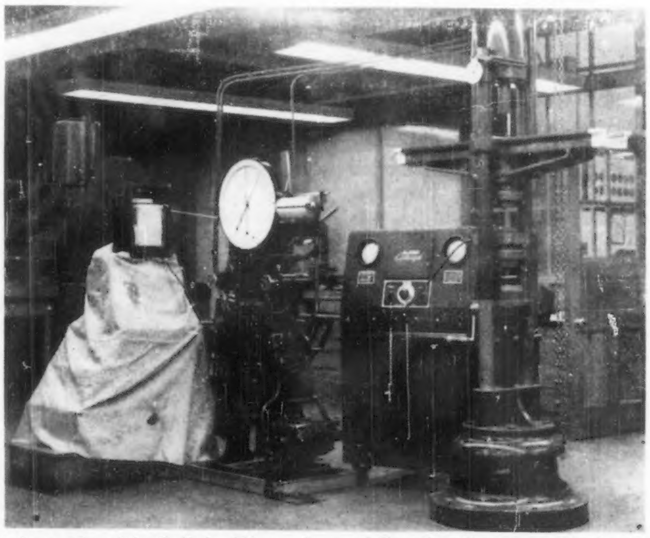

Fig. 1.—Cyclograph with Coil in Place Around Tension Specimen in Amsler Machine Esterline-Angus 1-mil. Recorder Driven from Amsler Records Cyclograph Output.

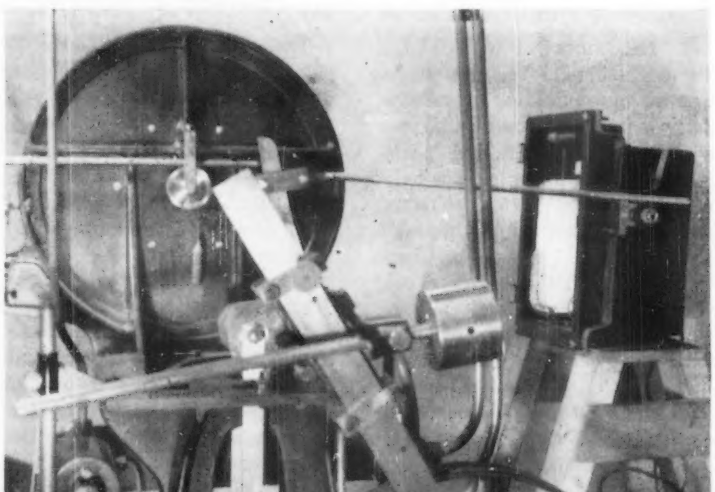

Fig. 2.—Showing Ratchet Attachment on Moving Hydraulic Counterweight Arm to Drive Recorder Paper Proportional to Stress. Spur on Recorder Gear Prevents Reversal of Paper. (See Fig. 7.)

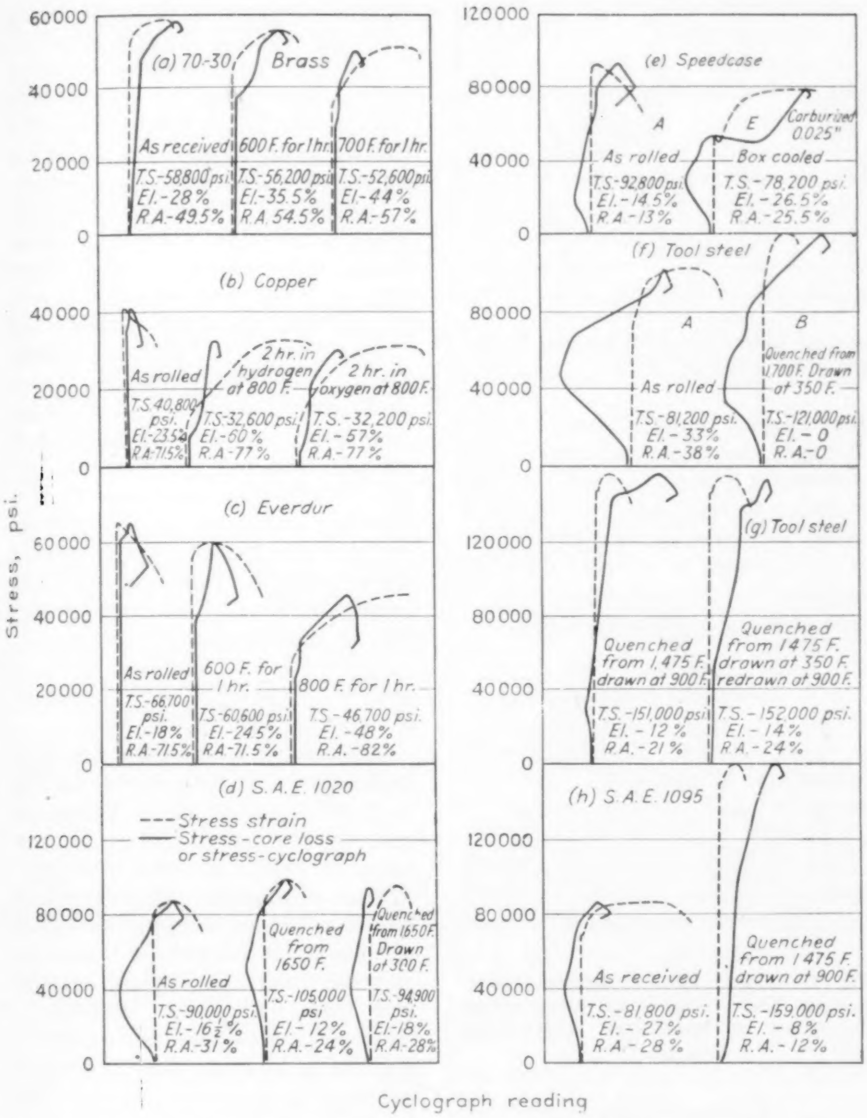

Fig. 3.—Comparisons of Stress-Strain and Stress-Core Loss Curves. All Samples Standard ½-in. Diameter Tension Specimens.

terials tested. Further work is in progress to settle this question. Figure 4 illustrates the sharp response of this method to the beginning of plastic deformation in brass.

A piece of metal will exhibit a certain relationship between total magnetic and eddy-current losses and small increases in applied stress below the elastic limit. This relationship appears to hold only so long as the metal has not been plastically deformed. If the metal has been plastically deformed, a new relationship is created. On this account, it is possible to distinguish between unworked and worked samples of the metal, given that a specimen of known characteristics is available. On this basis, all further work has been founded.

The above is not true for magnetic materials, unless the magnetic domains are always initially in the same condition of random orientation or complete alignment. The alignment of magnetic domains by external stress produces the initial rapid increase of total core losses shown in the curves of Fig. 3 for ferrous materials (**5**). In repeated tests on the same sample, vibrating the sample after stressing within the elastic range will bring the domains back to a state of random orientation when external stress is removed, so that further tests may be made on a comparative basis. This procedure must be carefully followed in all tests on ferrous metals.

The changes in magnetic properties in a ferro-magnetic material under stress can be more clearly understood if the conditions existing are considered in three separate stages in detail:

1. When small stresses are applied to a ferro-magnetic material, the first effect on the magnetic properties is due to the gradual alignment of magnetic domains. This phenomenon is the reverse of magnetostriction. A saturation point is reached when all the domains are in complete alignment. For an average ferro-magnetic material, this occurs at an external stress somewhere between one third and one half the yield point. Removal of external stress allows the domains to return to a condition approximating their original random orientation. The original condition will never be exactly duplicated, because of inertia or hysteresis effects in the movement of the domains. However, the resulting slight difference in magnetic properties from the original is hardly detectable by the Cyclograph at usual operating sensitivities even in hard ferro-magnetic materials where the hysteresis effect is most pronounced.

2. If external stress greater than that necessary to produce complete alignment of the domains but less than that which will produce plastic deformation is applied, a quite different effect is seen when the external stress is removed. The higher stress disturbs and possibly ruptures the bonds and inter-acting forces between domains. On removal of the external stress, the domains do not return to their original condition of random orientation but remain in partial or complete alignment. This condition produces a marked effect on the magnetic properties and can

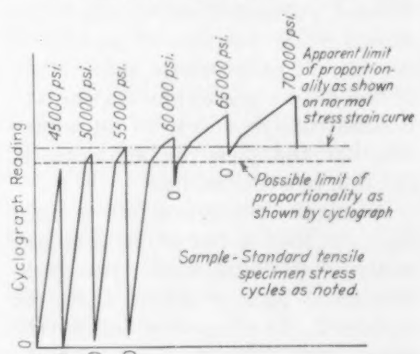

Fig. 4.—Change in Core Losses in 70:30 Brass Under Repeated Loading.

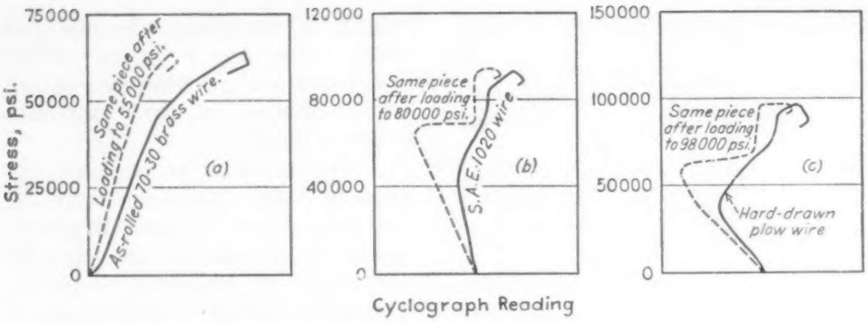

Fig. 5—Stress-Core Loss Curves for Same Specimen Before and After Loading Beyond the Elastic Limit. All Samples Were 0.050-in. Wire.

be readily detected by the Cyclograph.

The original random orientation can be reestablished by vibrating or hammering the sample.

3. If external stresses are great enough to produce some plastic deformation, internal stresses are set up in the metal which destroy the alignment of the domains and insure random orientation on removal of the external stress.

Failure Due to Overloading

If a piece of metal has been previously loaded beyond the elastic range so that plastic deformation has taken place, the change in total core losses caused by a certain change in stress will be markedly different than the change for the same piece of metal if previous loading has not exceeded the elastic range. This is true whatever the rate of previous plastic deformation.

The curves in Fig. 5 demonstrate this fact. If the standard stress-Cyclograph curve has been determined for a particular size and analysis of metal, applying a standard load to a similarly shaped piece of the same metal will at any time determine whether or not it has undergone plastic deformation. Stress-Cyclograph curves can be obtained while the piece of metal is in service. In other words, this method of test allows one to make a periodic nondestructive check to determine whether the piece is beginning to fail due to overloading.

A stress-Cyclograph curve may indicate that a particular size and analysis of metal with same heat-treatment history differs from the standard. In all cases so far investigated, such differences appear to be related to incipient failure. However, tension tests of such materials may suggest that they have become stronger, due to the fact that plastic deformation has increased their resistance to tensile stress. In such cases, evidence of incipient failure is readily seen in reduced ductility as measured by percentage elongation or lower endurance limit.

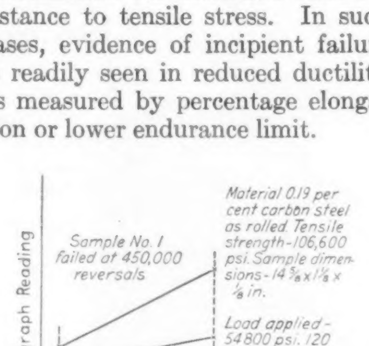

Fig. 6.—Change in Core Losses During Fatigue Test. From an Investigation Conducted at Rensselaer Polytechnic Institute (7).

Fatigue Failure

As described in a previous report (1), the Cyclograph can predict fatigue failure. There are definite limitations to this method of prediction, but its practical possibilities are very interesting. For example:

Figure 6 illustrates the difference in rate of change of core losses during fatigue in two steel test specimens with different fatigue life after the fatigue test had proceeded for some time. The Cyclograph is not sensitive to cracks or flaws, hence the initiation of fatigue cracks has no appreciable effect on the instrument.

Samples of ferrous and non-ferrous metals were subjected to repeated unidirectional tension below the limit of proportionality but greater than that value at which the stress-Cyclograph curve changes slope. Stress-Cyclograph curves made after this repeated loading are compared with the original curves for the same test specimens in Fig. 7. This test is analogous to the working conditions in such structures as mine-hoist ropes. Repeated unidirectional stresses below the elastic limit may not weaken the rope, but will reduce fatigue life.

Prediction of Failure in Mine-Hoist Rope

The foregoing demonstrates that high-frequency core losses can be used to detect incipient failure in metals where such failure is preceded by plastic deformation.

The continuous inspection of mine-hoist rope in service is a logical application of this test. A hoist rope in good condition, working at normal loads, will last indefinitely. However, corrosion, abrasion, bruising, and kinking may seriously weaken a rope locally and give rise to failure. Improper lubrication may also contribute to abrasion and fatigue.

Whatever the cause of failure, the unit stresses in the part of the rope where failure has started will be higher than in the rest of the rope. The higher unit stresses can be detected by the Cyclograph, since the

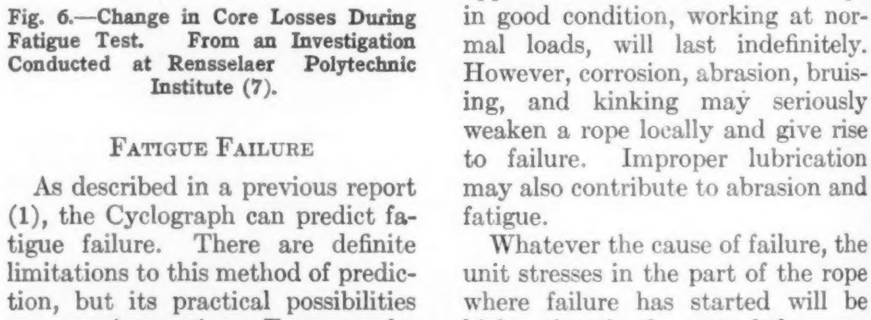

Fig. 7.—Stress-Cyclograph Curves Before and After Repeated Loading in Tension. All Test Specimens Were 0.050-in. Wire.

Note: Recorder paper driven as shown in Fig. 2. Compare with Fig. 5 where paper reversed as stress decreased.

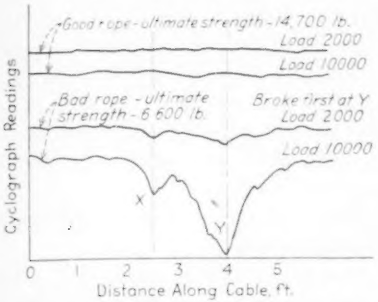

Fig. 8.—Variations in Recorded Cyclograph Output in Cable Under Load, Using ⅝-in. 6-19 Wire Rope.

The loads are given in pounds per sq. in.

core losses are different where the higher stresses occur.

Ultimately, the elastic limit will be exceeded in some or all of the load-carrying strands and some plastic deformation will take place. The stress-Cyclograph curve for this portion of the rope will then be different than it was before the elastic limit was exceeded, even though the tensile strength of the rope is not necessarily reduced. As failure proceeds, the Cyclograph reading at this point of incipient failure for some standard rope load will continue to change.

In practice, a Cyclograph recording is made of the condition of the rope over its entire length when it is first installed, and at definite intervals thereafter. Tests must be made with a known load on the rope. Any variation from the standard recorded pattern at any point in the length of a particular rope at a definite load can only be due to the beginning of plastic deformation. A limit can be set for allowable variation of the instrument reading from normal (Fig. 8). A reading beyond this limit at any point in the rope will indicate that it is no longer safe to use.

Continuous inspection can be used to record stresses in the rope. Such a record will also indicate whether safe working stresses are being exceeded in starting and stopping (6).

Field trials of this method of testing mine-hoist rope have been in progress for some time and will be reported on when completed.

Acknowledgments:

The author wishes to express his appreciation of the work done on this problem by R. S. Segsworth, General Engineering Co. (Canada) Limited, Toronto, Ontario, Canada, and of the assistance given by O. W. Ellis, of the Ontario Research Foundation.

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(3) A. V. de Forest, "Magnetic Determination of the Elastic State," *Transactions*, Am. Soc. Steel Treaters, Vol. 6, p. 653 (1924).

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(5) J. A. Ewing, "Magnetic Induction in Iron and Other Metals," Electrician Publishing Co., London, England (1891).
J. A. Ewing, "Magnetic Testing of Iron and Steel," *Proceedings*, Inst. Civil Eng., Vol. 126, p. 185 (1896).

(6) R. S. Segsworth, "Examination of Wire Rope with the Cyclograph," Report of General Engineering Co., Ltd., Toronto, Ontario, Canada, January, 1946.

(7) J. B. Duke, "A Qualitative Investigation of Core Losses in Metals with Approaching Fatigue Failure," Rensselaer Polytechnic Inst. Thesis, April, 1945.

DISCUSSION

MR. COMFORT A. ADAMS.[1]—Has there been any attempt on the part of the author of this paper to explain these core losses in terms of the damage he refers to?

MR. CAVANAGH (*author*).—The theoretical and fundamental basis of this work has been very ably covered in Germany in the last few years by Forster and Becker and in Canada by a member of the Bureau of Mines. As far as we are concerned, we have not as yet been concerned with finding out in a practical test whether damage is due to fatigue or due to overloading. We have had examples where we have tested cables which have been in service for a year and a half and we found that the recording deviated a great deal from what we expected. We took the whole cable and cut it into 6-ft. lengths. Some of the lengths were tested and the ultimate strength of the rope was found higher than normal.

However, the fatigue life of that rope, although no fatigue tests were made on it, I imagine was very much lower than normal. There are many situations where the results of such tension tests are going to show that the ultimate strength of the rope is higher and that deformation has taken place. In no instances where the strength was raised did we make any fatigue tests. There is no distinction made as to the different types of damage. Only continuing change in reading which indicates continuing damage (of either type) is regarded as important. Plastic deformation may increase the strength of the rope locally and prevent further fatigue or plastic deformation. In this case no further change in reading would occur at this point.

MR. ADAMS.—Did the core loss increase or decrease with damage?

MR. CAVANAGH.—It increases with damage if you are testing a magnetic material.

MR. ADAMS.—You showed some curves with peaks higher and higher, day after day.

MR. CAVANAGH.—The core loss was increasing.

MR. ADAMS.—That high core loss place was the place where it broke? Is that it?

MR. CAVANAGH.—Yes. If the damage is increasing, the core loss is increasing.

MR. O. W. ELLIS.[2]—There is now some evidence that these tests are going to be of practical value. At the present time the testing of mine ropes involves their partial destruction. If by a nondestructive type of test like this the presence of defects in ropes can be detected, so much the better.

I should like to mention one fact

[1] Consulting Engineer, Edward G. Budd Mfg. Co., Philadelphia, Pa.

[2] Director, Dept. of Engineering and Metallurgy, Ontario Research Foundation, Toronto, Ontario, Canada.

that impressed me in the work going forward on the small test equipment at the Ontario Research Foundation. In one of the curves of the type shown in Fig. 8 of the paper a defect was indicated as being present at a certain point in a rope. We, being inexperienced in the ways of mine cables and wire ropes, were quite unable to detect visually any defect in the rope at the point so clearly indicated by the Cyclograph.

It so happened that two or three days later members of the staff of the Department of Mines of the Province of Ontario came in to witness the test then proceeding. Their expert knowledge of the ways of wire ropes caused them to search along the length of the rope in the vicinity of the place where failure seemed to have occurred. One of the experts then noticed a slight, apparently unimportant, superficial defect at a point about four inches away from the place where the defect showed up on the Cyclograph chart. He took out his penknife and began picking away at the defect he had detected and eventually pulled out a wire which had broken at the point where the Cyclograph had indicated failure had occurred. This constituted rather impressive evidence that something had happened four inches from where a defect was apparent on the surface of the rope—something which had been shown up on the Cyclograph. I think there are great possibilities for this test, but there remains a tremendous amount of work to be done before we know exactly what the instrument is measuring.

Mr. H. F. Moore.[3]—As I understand it, it is not feasible with this apparatus to distinguish between cold work and fatigue damage to a metal. I understood the author to say that he assumed that if cold work had been done, the strength of the metal under *static* load would be increased, at least in most cases. From the experience we have had with cold work at the University of Illinois we should agree with that statement, but under repeated load, cold work if not too severe increases static elastic strength, increases tensile strength to a less degree, and if not too severe, or too often repeated, also increases the fatigue strength somewhat. I should like to ask the author if he feels that with his apparatus he can detect surely whether *fatigue damage* has been done to a metal.

Mr. Cavanagh.—I should say you can surely detect that there has been a change in the physical properties. As to whether the fatigue life has been increased or decreased, I am sure you know more about that than I do. Our feeling was that the rope had been damaged. It did not show up in the regular tension test. As a matter of fact, it may not have been damaged in fatigue. It may just have been changed. Under random fatigue overloads such as might be met in hoisting operations, it would be impossible to say that fatigue life would be reduced in every instance by overloads. There is some change in properties going on in the rope and that is all we know from these tests.

Mr. Paul A. Beck.[4]—I think it would be quite interesting to correlate the Cyclograph results with fatigue tests. If it is possible to predict fatigue failure by this method, it could be used for periodic inspection of propellers and machine parts which usually fail by fatigue.

Mr. Cavanagh.—We are very much interested in the possibility of predicting fatigue failure in normal fatigue tests. I do not see a great deal of practical application in this field myself but others might. We have used the instrument in some special instances to try to do just that, but our results are not yet completed. Some of them are extremely interesting. We are proceeding slowly so as to be quite sure of what we are doing before drawing any conclusions.

We have been using the instrument on some rolling load tests for rail fatigue, for instance, and have found some very interesting changes in slope of our curve before the rail shows cracks on the compression side. What that means, we are not prepared to say yet.

We are also conducting tests on a a rotating-beam fatigue machine and find some interesting changes in slope in these tests before we can detect any failure by normal methods. I am afraid that any conclusions on those results will have to wait until we have collected a great deal of data.

Mr. Adams.—What frequency was employed?

Mr. Cavanagh.—Between two thousand and two hundred thousand cycles per second. The particular frequency for any test is chosen to give nearly linear correlation between core losses and stress, and as great a flux penetration as possible.

Mr. Adams.—The electromagnetic phenomena in the cylindrical specimen, the wire, under those frequencies, are pretty definitely computable and particularly at the higher frequencies are confined very largely to the skin of the material. The reason for my first question as to the connection between the two, was connected with that fact. The more you know the reason why of things, the more you can figure them out, the better able you will be to interpret the results intelligently. I think there are great possibilities there.

Mr. Cavanagh.—That is being done. We are working now on the theoretical explanations for the results we are obtaining. Some of that work is being done in conjunction with Mr. Wlodek at the Bureau of Mines in Ottawa, Canada, and I believe we will have some material soon.

Mr. Adams.—Most of your defects are on the outside of the cable, are they not?

Mr. Cavanagh.—Most defects do occur on the surface of a cable but internal defects are also detectable at the frequencies between two and five thousand cycles. We choose frequencies to give us the results we want. For larger cables the frequencies run around three or four thousand cycles which apparently gives us sufficient penetration to detect defects through the entire cable.

Mr. Adams.—What size cable?

Mr. Cavanagh.—Up to $1\frac{1}{4}$ in. At the low flux density used, permeability is quite low, giving many times the penetration usually obtained at these frequencies using

[3] Research Professor of Engineering Materials, Emeritus, University of Illinois, Urbana, Ill.

[4] Associate Professor of Metallurgy, Notre Dame University, Notre Dame, Ind.

stronger fields. You do get much more penetration in stranded cable than you do on the solid bar, a great deal more. You don't get anything like as much at the higher frequencies and of course it is not uniformly distributed over the section. Even at one thousand cycles, you get much less flux density in the center of the field. One interesting feature about the little incident to which Mr. Ellis referred was the fact that the defect detected was in the interior. One fundamental thing we emphasize is the fact we are not detecting defects in the wire. We are detecting an increase in stress. If a wire is carrying more than its share of load, the unit stress is higher. Actually an interior defect throws more stress on the outer wires, outer defects throw more on the interior wires. Some problems are made a little simpler by these facts than at first appears.

Mr. Burt L. Newkirk[5] (*by letter*).—Several of our students at Rensselaer Polytechnic Institute have made studies and tests on the general problem of finding some nondestructive test of the progress of fatigue of metal. All used the same means of fatiguing the specimens. This consisted of two columns supporting on knife edges a piece of cold-rolled steel $\frac{1}{8}$ in. thick, 1 or $1\frac{1}{8}$ in. wide, depending on stock available, and approximately $14\frac{5}{8}$ in. long. An electromagnet set under the middle of the specimen was energized with 60-cycle current, and caused the specimen to vibrate near resonance at 120 cycles with an amplitude that could be adjusted and measured with fair accuracy.

Mr. K. F. Paulovich first tried to determine whether the progress of fatigue was accompanied by changes in the frequency of natural vibration of the specimen. He found some variation as fatigue progressed but this was not confirmed by subsequent studies, which showed very little change in natural frequency up to the time when fine surface cracks could be found with a microscope, or by a Magnaflux test. For one specimen, after the natural frequency had dropped only one and one-half cycles per second, a tension test showed the characteristic fatigue fracture over almost half the area of the break. This suggested a progressive embrittlement along certain areas within the metal, rather than progressive fracture, developing through any considerable fraction of the fatigue history of the specimen. Any progressive fracture would certainly have made observable changes in the natural frequency of the specimen.

Mr. J. B. Duke (Ref. 7) using the Du Mont Cyclograph, measured the core losses of the specimens at successive stages of fatigue. This was done for specimens in the cold-rolled condition and for other specimens from the same strip that had been annealed. Changes were noted in both lots, but in opposite directions. Mr. Cavanagh has suggested an explanation for this behavior (Ref. 1). The changes observed for the annealed specimens were quite regular and progressive. This finding seems to be supported by Cavanagh's finding that plastic changes affect readings made with the Cyclograph. In Duke's work, the plastic deformations must have been very minute, since it took about half a million reversals to produce the first detectable cracks.

[5] Professor of Vibrations, Theory and Practice, Rensselaer Polytechnic Inst., Troy, N. Y.

Investigation of Methods of Determining the Weight or Average Thickness of Tin on Tin-Coated Copper and Brass

By K. R. Hanna[1]

Summary

With a view to suggesting rapid, dependable, and low-cost methods of determining the average thickness of tin coatings on copper and brass, the author has critically studied fifteen methods which have been proposed for the determination of the weight of tin coatings on copper and steel.

The method recommended involves the selective stripping of tin in a boiling solution of sodium hydroxide containing suspended bismuth hydroxide. Two other methods involving the use of a sodium hydroxide-potassium iodate solution and a trichloroacetic acid solution, respectively, are suggested as alternatives.

The Standards Association of Australia, at whose request the investigation was carried out, required a description of methods which could be adopted as standard test procedures for determining the weight or average thickness of tin on tin-coated copper and brass dairy utensils and machinery.

The microscopic examination of transverse sections of tin-coated articles was not acceptable as a standard testing procedure since the preparation of specimens consumes much time and requires special skill. The Association required rapid tests in which the tin coating is removed without any measurable dissolution of the base metal.

Besides requiring a description of suitable testing methods, the Standards Association desired to be informed of any methods which had

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] An Officer of the Division of Industrial Chemistry, Council for Scientific and Industrial Research, Melbourne, Australia.

been adopted as standards by other organizations. The literature on the subject was therefore first reviewed; subsequent experimental work was based chiefly on the proposals found in the literature.

Previous Investigations

A search of the literature revealed that four methods had been proposed for determining the thickness of tin coatings on copper wire, and one "drop"[2] method for testing coatings on copper sheet. Seven methods of measuring the thickness of tin coatings on iron were also found, while two methods of selectively detinning practically any tin-coated metal had been suggested.

Four of the methods suggested for tin-coated iron (Nos. 1, 5, 7, and 8 in Table I) were obviously unsuitable for testing tin coatings on copper and brass. One of the methods proposed for coatings on iron (No. 6) and three which had been applied to tin-coated copper (Nos. 11, 13, and 14) appeared to be based on sound principles, but their application involved relatively lengthy experimental work and the use of special equipment. They were therefore considered unsuitable. Methods Nos. 2, 3, 4, 9, 10, and 12 were considered worthy of experimental trial.

[2] A "drop" test consists in measuring the time required for the complete removal of a small area of a tin coating with a solvent, drops of which are caused to impinge on the test specimen under prescribed conditions.

TABLE I.—OPINION BASED ON LABORATORY TRIALS OR LITERATURE REVIEW.

METHOD	COMMENTS	
	From Review of Literature	From Results of Experimental Trial
No. 1. A.S.T.M. Standard A 91 – 24[a] (*discontinued*)	Solvent (hot concentrated H_2SO_4) attacks copper and brass	....
No. 2. Sodium Plumbite[b]	....	Lead deposits on base metal in coherent form. Solution dissolves copper and brass slowly
No. 3. Hydrochloric Acid - Antimony Chloride[c]	....	Appreciable dissolution of base metal. Antimony deposits on portion of base metal in coherent form
No. 4. Ferric Alum - Hydrochloric Acid, Phosphoric Acid[d]	....	Appreciable dissolution of base metal
No. 5. Hydrochloric - Nitric Acid[b]	Solvent attacks copper and brass	....
No. 6. Electrolytic - Caustic Soda[b]	Dissolution of tin is slow. Copper and brass dissolve slowly at the anode. Requires electrolytic apparatus	....
No. 7. Magnetic[e]	Applicable only to a magnetic coating on nonmagnetic base or a nonmagnetic coating on a magnetic base	....
No. 8. Palm Oil[f]	Stripping of tin is slow, requiring 10 to 20 min. The high temperature required causes progressive formation of alloy layer and retention of tin	....
No. 9. Caustic Soda- Bismuth Hydroxide[g]	....	*Recommended.* Dissolution of tin rapid. No action on base metal or on intermediate alloy layer. Bismuth does not adhere firmly to specimen and can be converted to nitrate for re-use
No. 10. Caustic Soda - Potassium Iodate[g]	Expensive reagent used which cannot be re-used	*Recommended as Alternative.* Dissolution of tin rapid. No action on base metal or on intermediate alloy layer
No. 11. Ammonium Persulfate[h]	Involves accurate analytical work and is too slow	....
No. 12. Trichloracetic Acid[i]	Using "drop" method, special apparatus required. Complete removal of tin difficult to detect. Results may not give average thickness. Expensive reagent which cannot be re-used	*As a "drop" test:* Complete removal of tin difficult to detect visually. *As a "loss in weight" test: Recommended as alternative:* Dissolution of tin rapid and no action on base metal or alloy layer
No. 13. Electrolytic-Sulfuric Acid[j]	Elaborate electrolytic apparatus required	....
No. 14. Electrolytic-Stannous Chloride[k]	Electrolytic apparatus required	Using solution in "loss in weight" method, the dissolution of the tin is slow as compared with methods Nos. 9, 10, and 12. No action on base metal or alloy layer
No. 15. Caustic Soda - Hydrogen Peroxide	....	Excessive consumption of peroxide. The peroxide causes some appreciable and variable dissolution of copper and brass

[a] 1936 Book of A.S.T.M. Standards, Part I, p. 404.

[b] A. W. Hothershall, and W. N. Bradshaw, Tech. Pubn. Internat. Tin Res. and Develop. Council, Series A, No. 37.

[c] S. B. Clarke, Tech. Pubn. Internat. Tin Res. and Develop. Council, Series A, No. 12.

[d] C. Schumann, and H. Blumenthal, *Electrotech. Z.*, Vol. 48, p. 1295 (1927).

[e] B. Chalmers, W. E. Hoare, and W. H. Tait, Tech. Pubn. Internat. Tin Res. and Develop. Council, Series A, No. 66.

[f] W. E. Hoare, Tech. Pubn. Internat. Tin Res. and Develop. Council, Series A, No. 59.

[g] D. E. Torskŭ and P. J., Il'enko, *Konservnaya i Plodoovoshchnaya Prom.* (*Fruit and Vegetable Canning*), Vol. 10, pp. 6, 17 (1939).

[h] British Standards Institute B.S.S., CF(EL) 1407.

[i] G. B. Hogaboom, Jr., and N. Hall, *Metal Finishing*, Vol. 41, pp. 2, 89 (1943).

[j] G. G. Grower, "Electrolytic Determination of Tin on Tinned Copper Wire," *Proceedings, Am. Soc. Testing Mats.*, Vol. 17, Part II, p. 129 (1917).

[k] P. W. Seddon, *Metal Finishing*, Vol. 41, pp. 1, 37 (1943).

Experimental

The experiments were aimed at determining whether tin coatings could be rapidly and quantitatively stripped without any dissolution of the underlying copper and brass.

The solubility of uncoated copper and brass in each detinning solution was first determined; solutions which did not affect the base metals were then used for stripping typical coated specimens. In each experiment, the total quantity of detinning reagents employed was considerably greater than that theoretically required for the dissolution of the coating on the test samples. Method No. 12 was tried both as a "drop" test[2] and "loss in weight" test. In addition to trying the methods which had been proposed in the literature, some tests were made to ascertain whether a caustic soda - hydrogen peroxide mixture would selectively strip tin coatings.

The results of both the laboratory trials and the literature review are summarized in Table I.

Discussion of Results

The only solutions which cleanly and rapidly removed all the unalloyed tin without corroding the base metal were the sodium hydroxide solutions containing bismuth hydroxide and potassium iodate, respectively, and the trichloracetic acid solution. None of the solutions affected the copper-tin alloy layer between the base metal and the coating. It was considered that this did not detract from the value of tests involving the use of these solutions because:

1. The determination of the thickness of *tin* coatings, not alloy layers, was the main consideration.
2. The thickness of alloy layers appeared to be negligible as compared with the thickness of even thin tin coatings.

The stannous chloride-hydrochloric acid solution was selective in its action, but it dissolved tin more slowly than did the above solutions.

Recommendations

The sodium hydroxide-bismuth hydroxide method was recommended

as the standard testing procedure. A notable advantage of this method was that the bismuth nitrate used in the preparation of the detinning mixture could be recovered. This permitted an appreciable economy in regard to reagents.

Both the sodium hydroxide-potassium iodate and the trichloracetic acid solutions stripped the tin coatings as efficiently as the caustic soda-bismuth hydroxide mixture but there is no economical method of regenerating the iodate or the trichloracetic acid. The caustic soda-potassium iodate and the trichloracetic acid methods were therefore recommended as alternatives where cost and consumption of reagents were not important.

The following description of the standard testing procedures has been accepted by the S.A.A. as an Appendix to a proposed standard specification for milking machines.

Two alternative standard testing procedures are presented for estimating weight or average thickness of tin on tin-coated copper and brass sheets, tubes, or small parts (see Appendix).

APPENDIX

1. Caustic Soda-Bismuth Hydroxide Method (Standard Method)

(a) *Solutions Required:*

(1) Bismuth nitrate solution: 40 g. of bismuth nitrate; or 18 g. of metallic bismuth dissolved in 30 ml. of dilute nitric acid (1:30).

(2) Sodium hydroxide solution: 100 g. of sodium hydroxide dissolved in 1 liter of water.

(3) Sodium hydroxide-bismuth hydroxide mixture: made by adding (1) to (2).

(b) *Procedure:*

Three specimens shall be taken for testing. Specimens of sheet or tube shall be about 2 in. square. The three specimens shall be cleaned with carbon tetrachloride, benzol or petrol [gasoline], rinsed in alcohol, dried thoroughly, and weighed together (to the nearest 0.01 g). After weighing, each specimen shall be placed singly in a sling of nichrome wire, and immersed in 1 liter of boiling sodium hydroxide-bismuth hydroxide mixture prepared as described in Clause 1(*a*) (3). The same solution may be used for all three test pieces in turn. After immersion for 1 min, each specimen shall be removed, rubbed with a "policeman" or wetted rubber, washed, and inspected. This process of dipping, washing, and inspecting shall be repeated on each specimen until the coating has apparently been removed (see Note 1 below); the specimens shall then be rubbed (as above), washed in running water, rinsed in alcohol, dried, and weighed together. The above sequence of immersion, rubbing, washing, drying, and weighing shall be repeated until the total weight of the specimens remains unchanged. The three stripped specimens shall be weighed together to the nearest 0.01 g.

From the total loss in weight, the average thickness of the coating can be found by applying the following formula:

$$T = \frac{W}{A \times 118}$$

where

T = average thickness of tin coating, in inches,

W = total loss in weight of specimens, in grams,

A = total area of tin-coated surface, in square inches, and

118 = weight in grams of 1 cu. in. of tin.

Results shall be reported to the nearest 0.0001 in. (or to the nearest 0.01 g. per unit area).

(c) *Recovery of Bismuth:*

The bismuth in the detinning mixture may be recovered for re-use in the following manner:

At the completion of the test, a piece of pure tin (weighing approximately 50 to 100 g.) shall be immersed in the boiling solution for 5 min. The piece of tin shall then be removed and rubbed with a piece of wetted rubber, and washed to remove any loosely adhering bismuth. The solution shall be boiled again and filtered through a hardened filter paper, and the powdered bismuth washed thoroughly with hot water. The bismuth shall then be removed from the filter paper, dried by heating at 100 to 110 C. for 1 hr., and stored for re-use.

Note (1).—When the unalloyed tin has been removed, a lighter gray, smooth, alloy layer appears in place of the etched "crystalline" tin layer. The method described removes only the unalloyed tin which constitutes all but a very small proportion of the applied tin coating.

2. Caustic Soda-Potassium Iodate Method (Alternative Method)

(a) *Solution Required:*

Caustic soda-potassium iodate solution: 100 g. of sodium hydroxide and 20 g. of potassium iodate dissolved in 1 liter of water.

(b) *Procedure:*

The procedure and formula are the same as for the caustic soda-bismuth hydroxide method. It is not possible to recover the reagent for re-use.

3. Trichloracetic Acid Method (Alternative Method)

(a) *Solution Required:*

Trichloracetic acid solution: 100 g. of trichloracetic acid dissolved in 1 liter of water.

(b) *Procedure:*

The procedure and formula are the same as for the caustic soda bismuth hydroxide method. It is not possible to recover the reagent for re-use.

Tension and Torsion Creep Properties of Cloth Laminates*

By Joseph Marin[1]

SYNOPSIS

The purpose of this paper is to report tension and torsion creep-test data on three cloth-based laminates. Creep tests were made for round and tubular specimens and the data were interpreted by three methods—the log-log, the semi-log, and the hyperbolic sine methods. A theoretical correlation is given between the tension and torsion creep values based on a distortion energy criterion. This correlation permits the prediction of torsion-creep deformations when creep constants for tension are known. In order to select the stress values to be used for the creep tests and to obtain complete information on the static properties, tension, compression, and torsion, stress-strain diagrams were taken for each material.

THE three cloth-based laminated plastics tested were supplied by the Synthane Corp., Oaks, Pa., and are designated as L, C, and AA laminates in the Synthane catalog. The specimens for most of the tests were tubular with an inside diameter of about $\frac{1}{2}$ in. and an outside diameter of about $\frac{3}{4}$ in. Both the control and creep tests were made under humidity and temperature conditions approximating those conditions as specified by the A.S.T.M. in its Tentative Recommended Practice for Long-Time Tension Tests of Plastics.[2] The creep tests were conducted in a creep laboratory in which the humidity was controlled by both a humidifier and dehumidifier, and electrical heating units were used for raising the temperature when necessary.

STATIC TENSION, COMPRESSION, AND TORSION TESTS

Tension stress-strain data to rupture were obtained using a 60,000-lb. capacity Baldwin Southwark hydraulic machine. The specimens were gripped by collets and by use of steel plugs at the ends of the specimen. To prevent rupture of the tension specimens by stress concentration at the collets, the wall thickness of the central section was reduced. A specially designed averaging type strain gage (Fig. 1) with a 2-in. gage length was used for measuring tensile strains. Figure 2 shows the three stress-strain diagrams for each of the three laminates, and Table I gives the yield strength, ultimate strength, stiffness, and ductility values for each test. The yield strength is obtained by using the offset method[2] and the stiffness represents the average slope of the stress-strain diagram of modulus of elasticity between zero and 5000 psi. stress values. The ductility represents the percentage elongation at rupture. An examination of Table I shows that the strength, stiffness, and ductility in tension of the L and C laminates are approximately equal. For the AA laminate, however, the strength is about one half and the ductility about one third the values of the L and C laminates.

Compression control tests were made on tubular specimens about

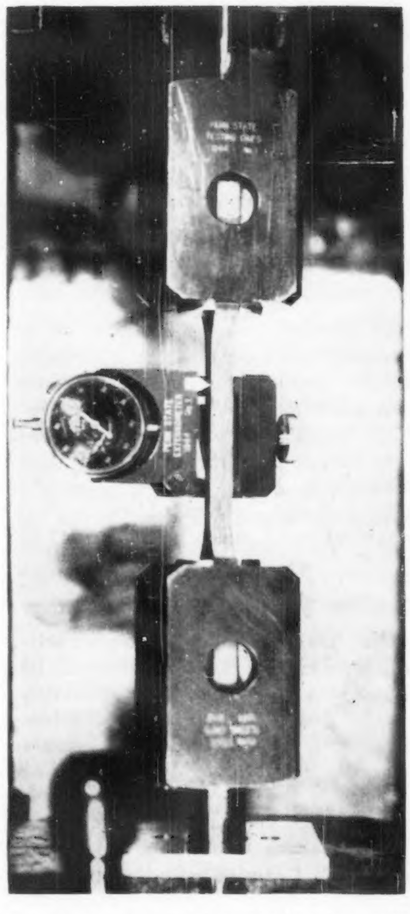

Fig. 1.—Averaging Type Strain Gage, with a 2-in. Gage Length.

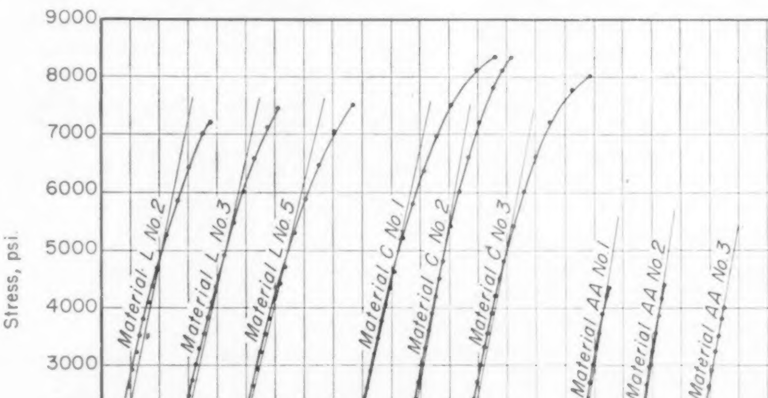

Fig. 2—Static Tension Stress-Strain Diagrams, Tubular Cross-Sections.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

* Presented at the Forty-Ninth Annual Meeting, Am. Soc. Testing Mats., Buffalo, N. Y., June 24–28, 1946.

[1] Professor of Engineering Mechanics, The Pennsylvania State College, State College, Pa.

[2] 1944 Book of A.S.T.M. Standards, Part III, p. 1711.

TABLE I.—MECHANICAL PROPERTIES IN STATIC TENSION.

Material	Specimen	Area, sq. in.	Yield Strength, psi.	Tensile Strength, psi.	Stiffness $E \times 10^{-6}$, psi.	Ductility, per cent
L.....	No. 2	0.171	6250	7200	0.96	0.94
	No. 3	0.183	7000	7450	0.88	1.03
	No. 5	0.170	6925	7500	0.81	1.18
	Average	...	6720	7380	0.88	1.03
C.....	No. 1	0.173	7250	8350	0.89	1.40
	No. 2	0.167	7400	8330	1.10	1.03
	No. 3	0.167	6450	8000	1.01	1.22
	Average	...	7030	8230	1.00	1.22
AA.....	No. 1	0.167	4350	4350	1.22	0.37
	No. 2	0.169	4400	4400	1.30	0.35
	No. 3	0.171	4000	4000	1.07	0.37
	Average	...	4250	4250	1.20	0.36

TABLE II.—MECHANICAL PROPERTIES IN STATIC COMPRESSION.

Material	Specimen	Area, sq. in.	Yield Strength, psi.	Compressive Strength, psi.	Stiffness $E \times 10^{-6}$, psi.	Ductility, per cent
L.....	No. 1	0.246	9000	27000	1.17	9.8
	No. 2	0.246	9000	25600	1.08	9.3
	Average	...	9000	26300	1.12	9.5
C.....	No. 1	0.246	8000	24000	1.50	8.2
	No. 4	0.246	7600	23800	1.41	7.1
	Average	...	7800	23900	1.45	7.6
AA.....	No. 1	0.246	5000	18700	1.22	2.9
	No. 2	0.246	5400	20600	1.91	3.2
	Average	...	5200	19650	1.56	3.0

2 in. long using a specially designed averaging type strain gage with a 1-in. gage length (Fig. 3). The slenderness ratios of the specimens were such that failure by buckling was prevented. The compression stress-strain diagrams for the three laminates are shown in Fig. 4, and the yield strength, ultimate strength, stiffness, and ductility values are given in Table II. The yield strength and stiffness values were determined in the same manner as in the tension tests. A comparison of values in Tables I and II shows that for the L and C materials the ultimate compressive strength is about three times the tensile strength, the modulus of elasticity in compression is about one and a half times the value in tension, and the ductility in compression is six to nine times as great as in tension. For the AA material similar ratios of the properties in tension and compression apply.

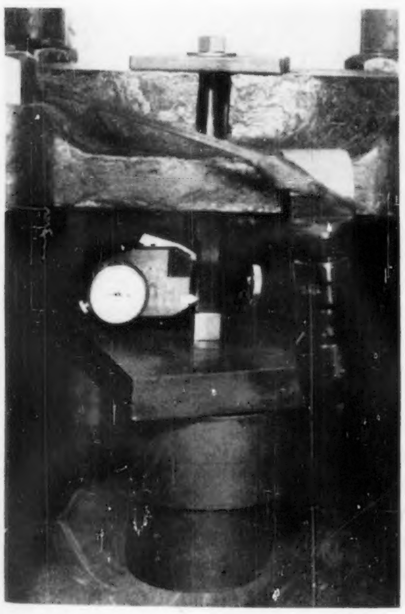

Fig. 3.—Averaging Type Strain Gage, with a 1-in. Gage Length.

Torsion tests were made using the torsion machine shown in Fig. 5. The torsion specimen shown has steel plugs inserted at the ends and is attached to horizontal shafts by means of collets. The shafts are supported on several closely spaced bearings. By means of these bearing supports, a load applied to the

TABLE III.—MECHANICAL PROPERTIES IN STATIC TORSION.

Material	Specimen	Outside Diameter, in.	Inside Diameter, in.	Tensile Strength, psi.	Unit Stiffness, $E_s \times 10^{-6}$, psi.	Ductility, per cent
L.....	No. 1	0.75	0.50	10850	0.370	8.0
	No. 2	0.75	0.50	10650	0.353	7.5
	Average	...	..	10750	0.361	7.8
C.....	No. 1	0.75	0.50	7650	0.338	6.2
	No. 2	0.75	0.50	7280	0.319	5.3
	Average	...	..	7465	0.328	5.8
AA.....	No. 1	0.75	0.50	4290	0.358	2.2
	No. 2	0.75	0.50	4880	0.354	2.5
	Average	...	..	4585	0.356	2.4

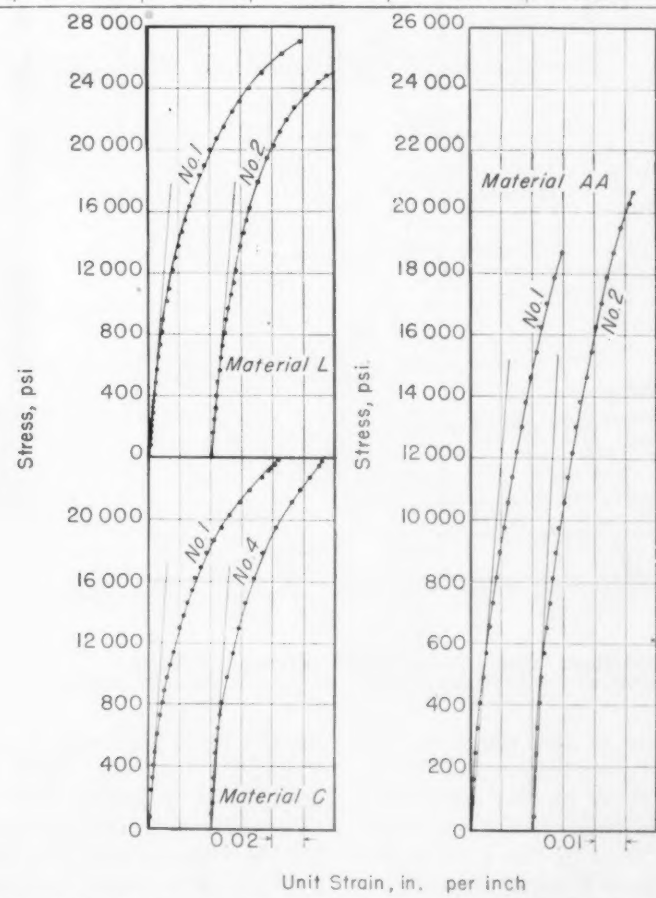

Fig. 4.—Static Compression Stress-Strain Diagrams, Tubular Cross-Sections.

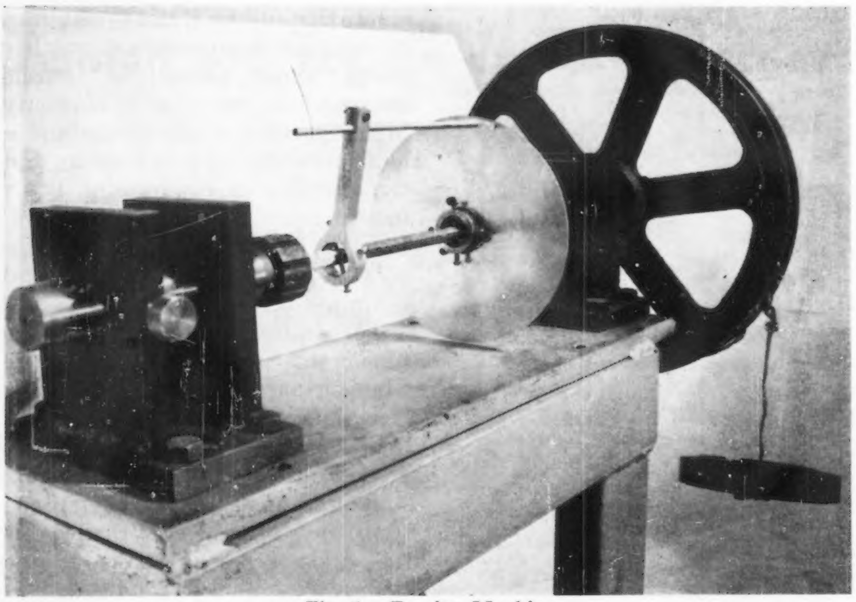

Fig. 5.—Torsion Machine.

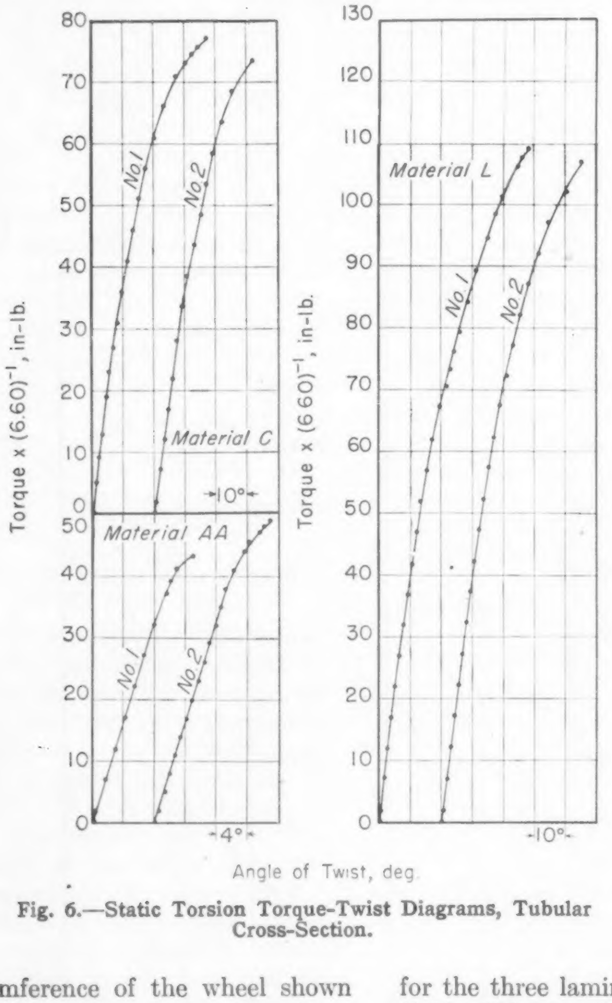

Fig. 6.—Static Torsion Torque-Twist Diagrams, Tubular Cross-Section.

circumference of the wheel shown produces a pure torque free from transverse shear on the specimen. The angle of twist during a torsion test is measured by the twistmeter shown. Figure 6 shows the torque angle-of-twist diagrams to rupture for the three laminates tested, and Table III lists the values of the mechanical properties in torsion obtained from these tests. In Table III the ultimate strength and stiffness are determined, assuming the elastic theory is applicable. Although this assumption is incorrect for both the strength and stiffness calculations, the quantities obtained will be of value for purposes of comparison. The angle-of-twist values at rupture are given in Table III and are indicative of the ductility in torsion. A comparison of the values in Tables I and III shows that the stiffness or modulus of elasticity in torsion is about one third the value in tension for the three laminates tested. The ultimate strength values for torsion and tension for the C and AA materials is about the same. The torsional strength of the L laminate is considerably higher than its tensile strength.

Tension Creep Tests

Tension-Creep Results:

Tension-creep tests on tubular specimens with about ½-in. inside diameter and about ¾-in. outside diameter were made using the creep machine shown in Fig. 7. Creep-strain readings for each specimen were observed using a micrometer microscope strain gage and black ink target points placed on a white background (Fig. 8). A 10-in. gage was used to increase the accuracy of the creep-strain values obtained.

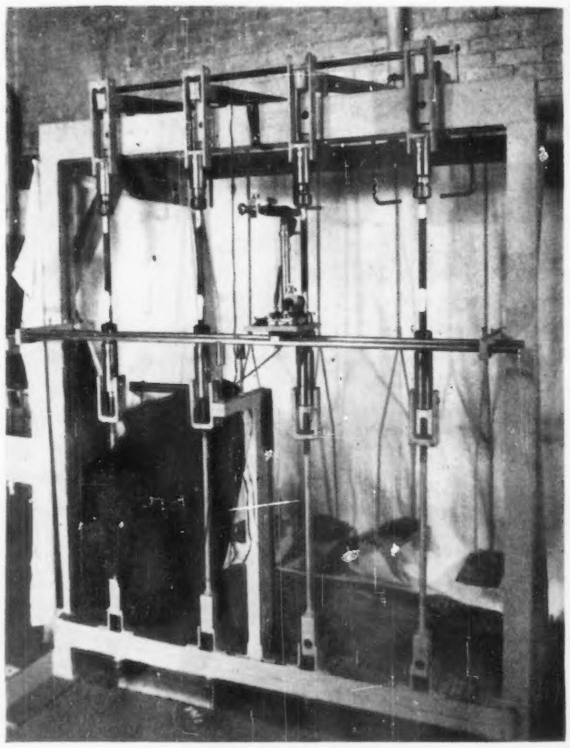

Fig. 7.—Tension Creep Machine.

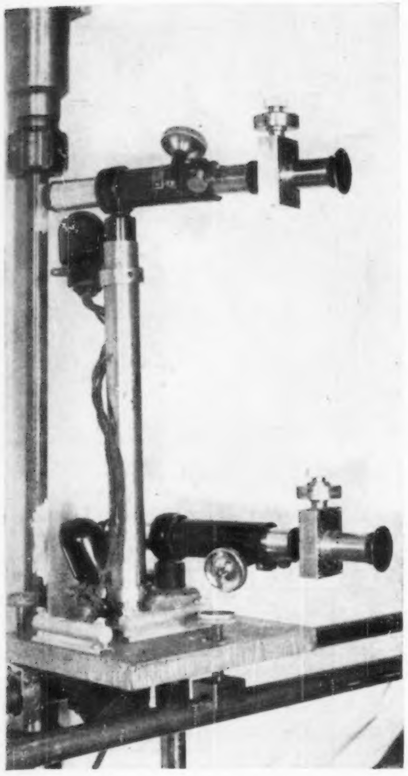

Fig. 8.—Machine Used for Taking Creep-Strain Measurements.

Except for the gage length selected, the tests followed the Federal Specifications (**1**).[3] Creep readings for various stress values were taken at selected time intervals for a period of 1000 hr., and the creep-time data obtained are plotted in Figs. 9, 10, and 11.

Creep-time relations for plastics are sometimes plotted on a log-log basis (**2**), and for many tests straight-line relations between creep strain and time have resulted by plotting in this manner. For the data shown in Figs. 9, 10, and 11, after an initial period, the creep-time relation can be approximated by a straight line or constant creep rate as shown. The assumption of a constant creep rate has important advantages since a stress-creep rate relation can be obtained for the purpose of selecting a design stress (**2**).

Creep-strain values at 1000 hr. for each material and stress are given in Table IV. These values include both the elastic and creep strain as usually reported. Table IV also gives the constant creep-rate values. The constant creep rate represents the slope of the creep-time plots after the initial stage. Using the values given in Table IV for creep and stress, a comparison of the creep strains at 1000 hr. for the three laminates can be made as shown in Fig. 12. Figure 12 shows that the creep in laminate L at 1000 hr. is considerably greater than for the C or AA laminates. Table V was prepared using the curves in Fig. 12 and gives a comparison of

[3] The boldface numbers in parentheses refer to the references appended to this paper.

TABLE IV.—STATIC TENSION CREEP TEST DATA.

Material	Specimen	Area, sq. in.	Load, lb.	Stress, psi.	Creep Rate, C_t, in. per in. per hr. $\times 10^7$	Creep, e_t, at 1000 hr., in. per in. $\times 10^3$
L.....	No. 1	0.282	874	3100	15.0	8.25
	No. 2	0.250	1054	4220	21.5	15.00
	No. 3	0.250	1337	5350	47.5	21.50
	No. 4	0.246	1712	6970	...	...
	No. 5	0.246	1575	6400	...	...
	No. 6	0.245	1431	5840	...	...
C.....	No. 1	0.246	1472	5900	47.70	11.75
	No. 2	0.246	1118	4550	22.30	6.65
	No. 3	0.246	881	3580	11.42	2.25
	No. 4	0.246	674	2740	8.28	1.62
AA.....	No. 1	0.242	874	3610	4.30	2.85
	No. 2	0.245	1053	4310	5.25	4.00
	No. 3	0.245	1337	5470	...	...
	No. 4	0.245	1430	5850	...	...
	No. 5	0.245	1257	5140	...	...
	No. 6	0.245	643	2630	...	...
	No. 7	0.245	736	3010	3.75	2.01

TABLE V.—COMPARISON OF CREEP DEFORMATIONS.

Type of Creep Test	Type of Cross-section	Stress, psi.	Creep Deformation[a]		
			L	C	AA
Static tension strain at 1000 hr.	Round	500	1.6	0.41	0.26
		1000	3.1	0.92	0.62
		1500	4.7	1.54	0.78
		2000	6.2	2.38	1.05
		2500	7.8	3.90	1.30
		3000	9.3	...	1.56
		3500	10.9	...	1.83
		4000	12.8[b]	...	2.14[b]
	Tubular	1000	1.4	0.1	0.47
		2000	4.0	0.6	1.11
		3000	7.8	1.7	2.00
		4000	13.0	4.1	3.48
		5000	19.8	8.0	...
		6000	29.1[b]	12.2[b]	...
Static torsion angle of twist at 1000 hr.	Tubular	500	0.06	0.47	0.27
		1000	0.25	0.94	0.55
		1500	0.56	1.40	0.83
		2000	1.02	1.87	1.10
		2500	1.62	2.34	1.38
		3000	2.38	2.80[b]	1.65[b]
		3500	3.22	...	1.93[b]
		4000	4.20	...	2.21[b]
		4500	5.26	...	2.49[b]
		5000	6.40	...	2.76[b]

[a] For static tension the units are inches per inch $\times 10^3$; for static torsion the units are degrees per inch.
[b] Extrapolated values.

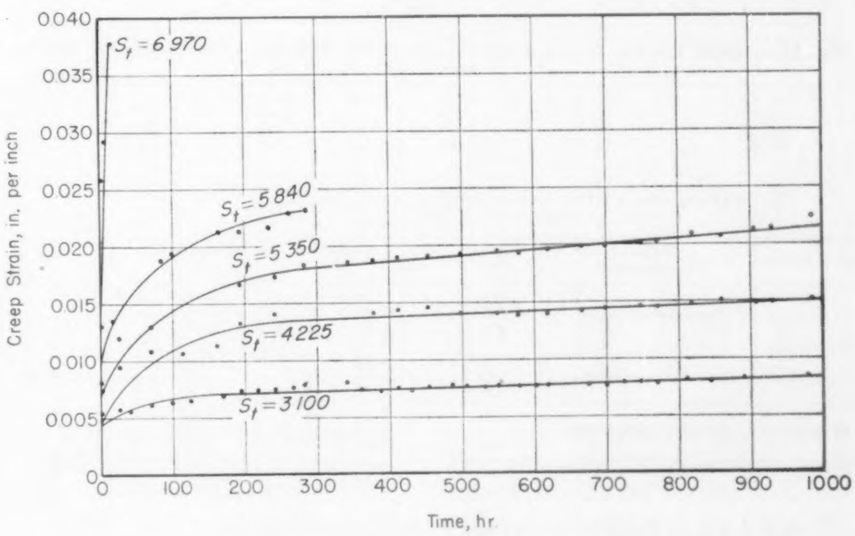

Fig. 9.—Static Tension Creep-Time Relations for Tubular Cross-Sections, with Material L.

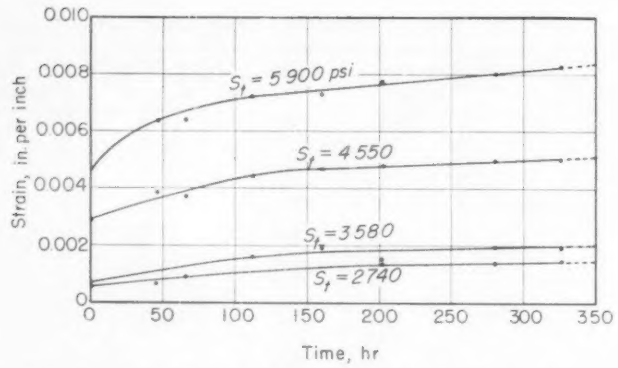

Fig. 10.—Static Tension Creep-Time Relations for Tubular Cross-Sections, with Material C.

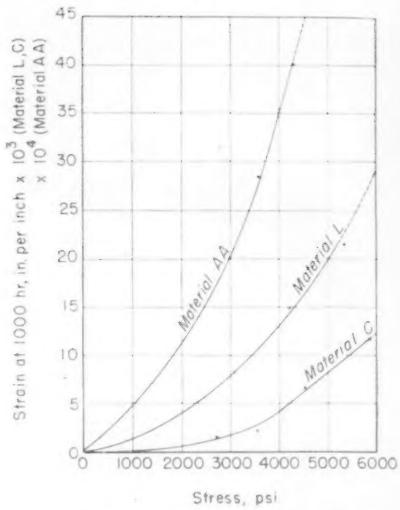

Fig. 12.—Comparison of Static Tension Creep Strains, Tubular Cross-Sections.

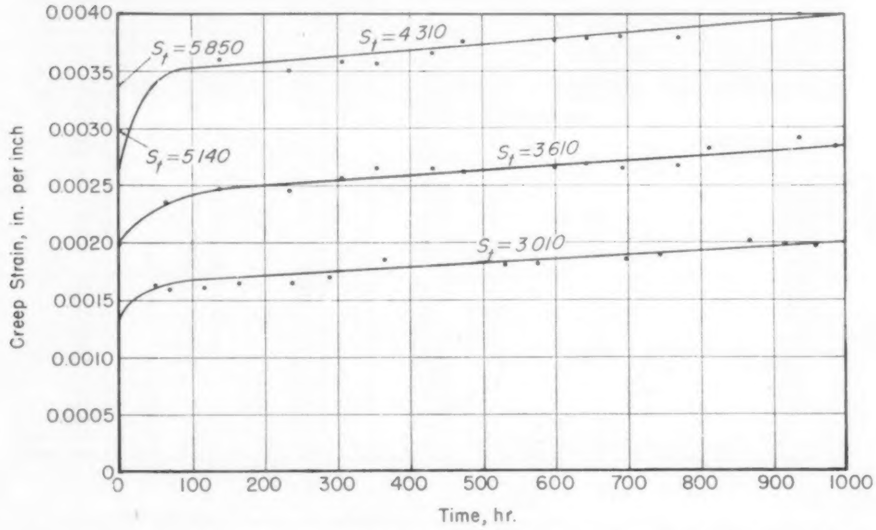

Fig. 11.—Static Tension Creep-Time Relations for Tubular Cross-Sections, with Material AA.

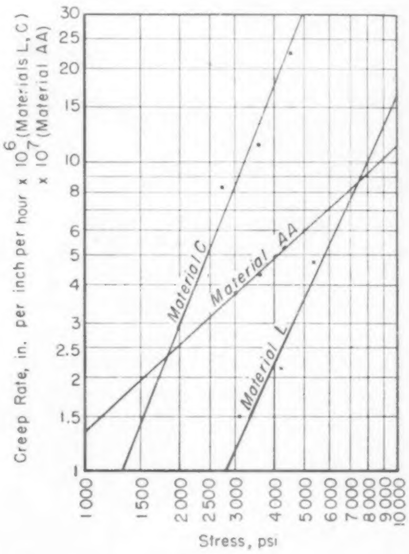

Fig. 13.—Comparison of Creep Rate-Static Tension Stress Relations, Tubular Cross-Sections, Using the Log-Log Method.

TABLE VI.—CREEP RATE-STRESS CONSTANTS.
B and n in $C = BS^n$

Type of Stress	Type of Cross-section	Material	Constant B	Constant n
Static tension	Round specimens	L.......	1.24×10^{-13}	2.02
		C.......	6.28×10^{-11}	1.15
		AA.......	3.09×10^{-12}	1.40
	Tubular specimens	L.......	1.11×10^{-14}	2.19
		C.......	9.55×10^{-16}	2.57
		AA.......	1.08×10^{-10}	0.93
Static torsion	Tubular specimens	L.......	4.47×10^{-16}	3.11
		C.......	2.25×10^{-14}	2.98
		AA.......	3.03×10^{-9}	1.39

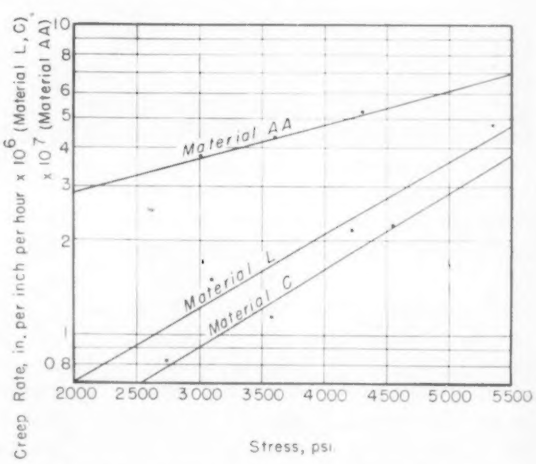

Fig. 14.—Comparison of Creep Rate-Static Tension Stress Relations, Tubular Cross-Sections, Using Log Method.

TABLE VII.—CREEP RATE-STRESS CONSTANTS B_1 AND D_1.
in $\log C = B_1 + D_1S$

Type of Stress	Type of Cross-section	Material	Constant $D_1 \times 10^4$	Constant B_1
Static tension	Round specimens	L.......	3.20	6.88
		C.......	3.62	7.16
		AA.......	2.95	7.52
	Tubular specimens	L.......	2.35	6.62
		C.......	2.47	6.78
		AA.......	1.11	6.76
Static torsion	Tubular specimens	L.......	4.23	4.98
		C.......	5.02	4.82
		AA.......	3.10	4.56

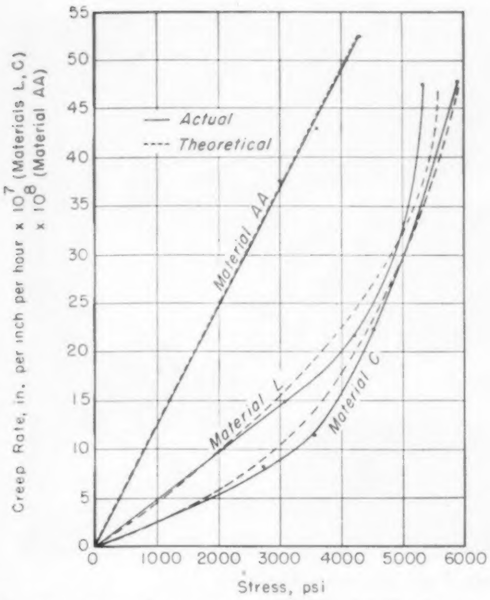

Fig. 15.—Comparison of Creep Rate-Static Tension Stress Relations, Tubular Cross-Section, Using Hyperbolic Sine Method.

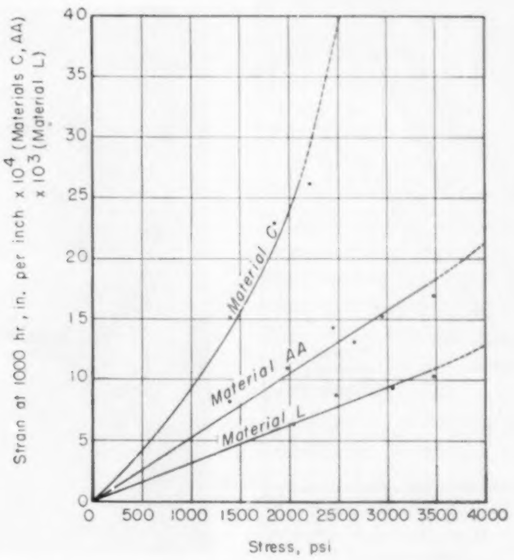

Fig. 16.—Comparison of Static Tension Creep Strains Using Round Cross-Sections.

TABLE VIII.—CREEP RATE-STRESS CONSTANTS S_1 AND C_1. in $C = C_1 \sinh S/S_1$

Type of Stress	Type of Specimen	Material	Constant C_1	Constant S_1
Static tension	Round specimens	L.......	22.50×10^{-8}	1200
		C.......	18.00×10^{-8}	1382
		AA.......	6.62×10^{-8}	1458
	Tubular specimens	L.......	15.20×10^{-7}	3360
		C.......	4.97×10^{-7}	2010
		AA.......	...	...
Static torsion	Tubular specimens	L.......	1.27×10^{-5}	960
		C.......	2.32×10^{-5}	760
		AA.......	3.53×10^{-6}	1100

TABLE IX.—STATIC TENSION CREEP TEST DATA WITH ROUND CROSS-SECTIONS.

Material	Specimen	Area, sq. in.	Load, lb.	Stress S_t, psi.	Creep Rate, C_t, in. per in. per hr. $\times 10^7$	Creep (e_t) at 1000 hr., in. per in. $\times 10^3$
L.....	No. 1	0.0491	100	2040	6.00	6.45
	No. 2	0.0491	150	3050	10.00	9.25
	No. 3	0.0491	171	3480	17.50	10.25
	No. 4	0.0491	122	2480	9.60	8.72
C.....	No. 1	0.0491	171	3470	...	...
	No. 2	0.0495	132	2660	5.50	4.58
	No. 3	0.0495	145	2920	...	...
	No. 4	0.0495	110	2220	4.45	2.62
	No. 5	0.0495	92	1860	4.03	2.30
	No. 6	0.0491	69	1400	2.23	1.51
AA.....	No. 1	0.0491	171	3470	2.65	1.70
	No. 2	0.0495	132	2660	...	...
	No. 3	0.0491	145	2950	2.25	1.53
	No. 4	0.0491	110	2440	1.60	1.43
	No. 5	0.0491	92	1880	1.22	1.09
	No. 6	0.0491	69	1400	0.79	0.82

the creep strains for specific stress values.

Interpretation of Tension-Creep Test Results:

Three methods of interpretation of the creep results were used. The log-log and semi-log were selected because these have been found for several years to be the most adequate (**2**), and the newer hyperbolic sine method proposed by Nadai (**3**) was considered since this method has been found satisfactory in some recent investigations (**4**). By these methods the constant creep rate C represents the slope of the creep-time relations (Figs. 9, 10, and 11), and the stresses are assumed to be defined by one of the following relations:

Log-log method $C = BS^n$............(1)

Log method $\text{Log } C = B_1 + D_1S$.......(2)

Hyperbolic sine method

$$C = C_1 \sinh \frac{S}{S_1} \quad \text{........(3)}$$

where:

C = the constant creep rate
S = the stress,

and B, n, B_1, D_1, C_1, and S_1 are material constants to be determined for each particular set of test data.

For the log-log method the constants B and n in Eq. 1 can best be determined by plotting the creep rate C and stress values S on log-log paper as shown in Fig. 13 for the three laminates. The n value then represents the slope of the assumed straight line representing the test points, and the B value is the intercept of this straight line on the creep axis. Values of B and n are given in Table VI for the three materials tested.

For the log method a semi-log plot can be used as shown in Fig. 14. The constants representing the average straight lines in Fig. 14 are given in Table VII.

A method for determining the constants using the hyperbolic sine method is explained in Appendix I. This procedure is believed to be an improvement over the method suggested by Nadai and McVetty (**4**). A comparison of the test points with the hyperbolic sine relation is shown in Fig. 15. The constants C_1 and S_1 in the hyperbolic sine relations are listed in Table VIII.

An examination of Figs. 13, 14, and 15 shows that no conclusion can be reached regarding which method of interpretation gives the best agreement with the test data. The

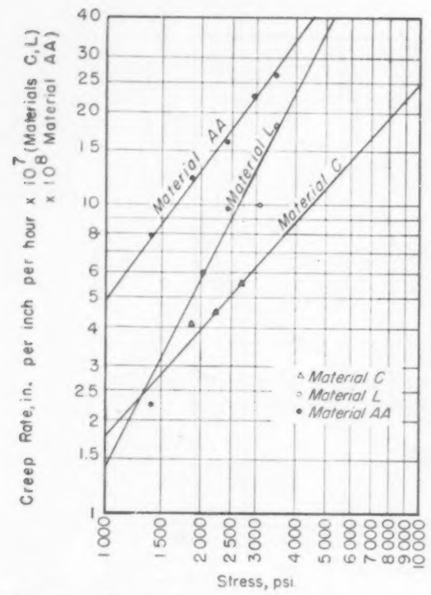

Fig. 17.—Comparison of Creep Rate-Static Tension Stress Relations for Round Cross-Sections, Using Log-Log Method.

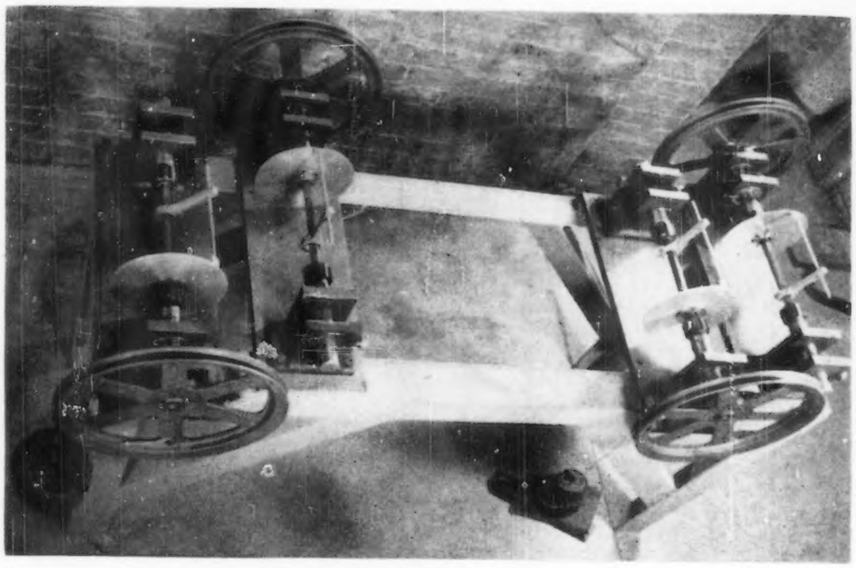

Fig. 20.—Four-Unit Torsion-Creep Machine.

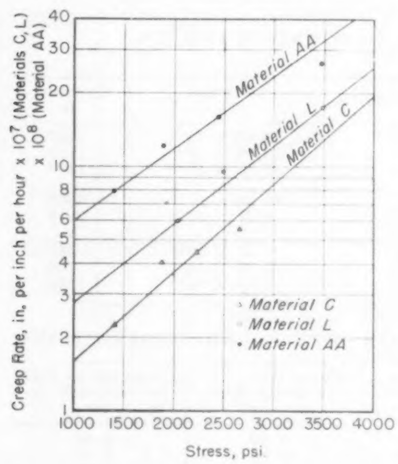

Fig. 18.—Comparison of Creep Rate-Static Tension Stress Relations for Round Cross-Sections, Using Log Method.

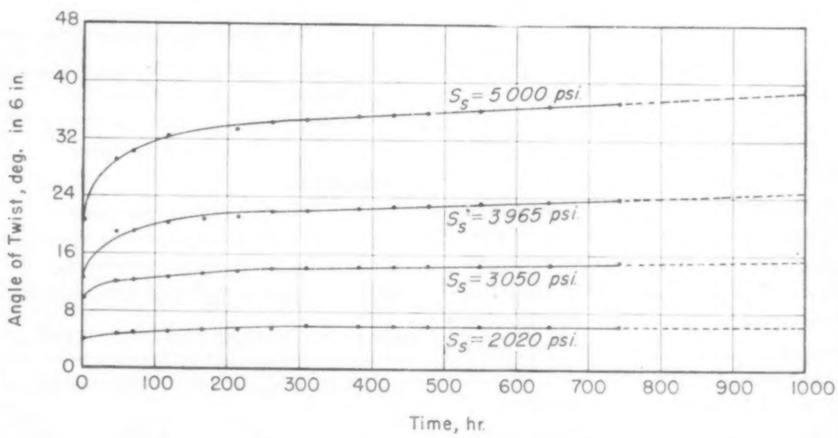

Fig. 21.—Static Torsion Creep-Time Relations for Tubular Cross-Sections, with Material L.

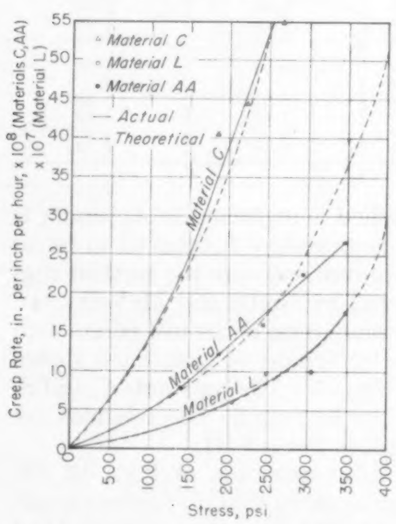

Fig. 19.—Comparison of Creep Rate-Static Tension Stress Relations for Round Cross-Sections, Using Hyperbolic Sine Method.

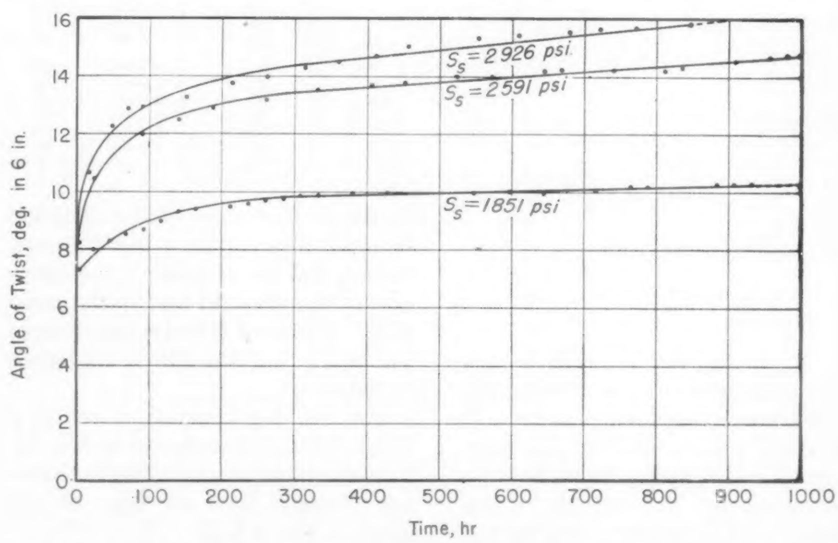

Fig. 22.—Static Torsion Creep-Time Relations for Tubular Cross-Sections, with Material C.

TABLE X.—STATIC TORSION CREEP TEST DATA.

Material	Specimen	Dimensions, in.		Twisting Moment, in-lb.	Shear Stress, S_s, psi.	Creep Rate, C_s, deg. per in. per hr. × 10^5	Creep Angle at 1000 hr., deg. per in.
		Outside Diameter	Inside Diameter				
L...	No. 3a	0.75	0.50	134	2020	5.0	1.03
	No. 1	0.75	0.50	203	3050	30.0	2.53
	No. 4	0.75	0.50	263	3960	63.3	4.12
	No. 2	0.75	0.50	332	5000	93.3	6.43
C...	No. 5	0.75	0.50	123.0	1850	11.7	1.72
	No. 6	0.75	0.50	172.0	2590	33.5	2.46
	No. 7	0.75	0.50	194.5	2920	45.0	2.71
AA...	No. 3	0.75	0.50	80.0	1200	8.25	0.60
	No. 4	0.75	0.50	113.3	1700	9.66	1.05
	No. 5	0.75	0.50	147.5	2220	10.00	1.20
	No. 6	0.75	0.50	177.8	2680	19.20	1.51

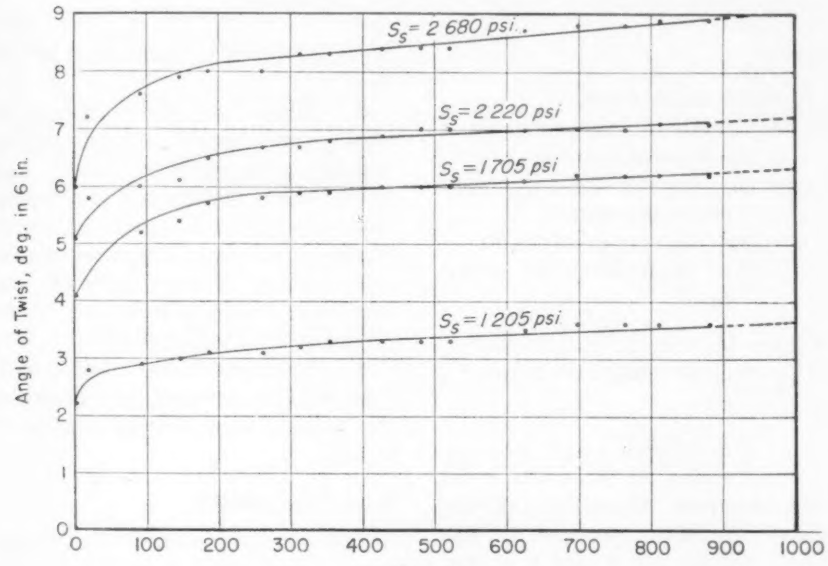

Fig. 23.—Static Torsion Creep-Time Relations for Tubular Cross-Sections, with Material AA.

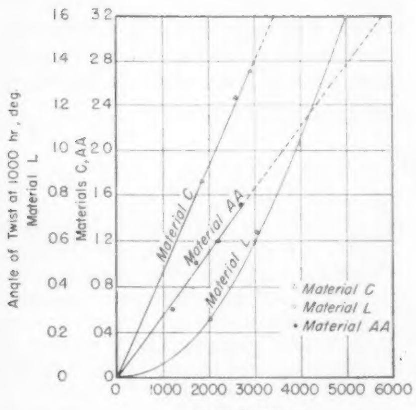

Fig. 24.—Comparison of Static Torsion-Creep Angles of Twist for Tubular Cross-Sections.

experimental data, however, can be approximately expressed by any one of these methods.

Tension-creep tests on solid specimens of round cross-sections ¼ in. in diameter were made on the three laminates L, C, and AA. The creep strains at 1000 hr. and the creep rates are given in Table IX. Figure 16, based on Table IX, gives a comparison of the creep strains of the materials for various stress values. The three methods of interpretation used for the tubular specimens were applied to the test data for round specimens and the results are shown in Figs. 17, 18, and 19. The material constants obtained from these curves are given in Tables VI, VII, and IX. As for the tubular tension specimens, any one of the three methods can be considered as approximately representing the test data. Tables V and IX show that there is approximate agreement between the creep values for tubular and solid round specimens subjected to tension.

Torsion-Creep Tests

The torsion-creep tests on tubular specimens were made in the four-unit torsion-creep machine shown in Fig. 20. A single unit of this machine is shown in Fig. 5. Weights and torques of fixed magnitudes can be applied to the wheels shown in Fig. 5, and the creep angle of twist can be measured at selected time intervals using a twistmeter. Creep-time relations for the three laminates representing variation in creep angle and time are shown in Figs. 21, 22, and 23 for various stress values. The creep strains and creep rates, as obtained from these curves are given in Table X. A comparison of the torsion-creep values of the three laminates is given in Fig. 24 and shows that the creep at 1000 hr. is greatest for the L material and least for the AA laminate.

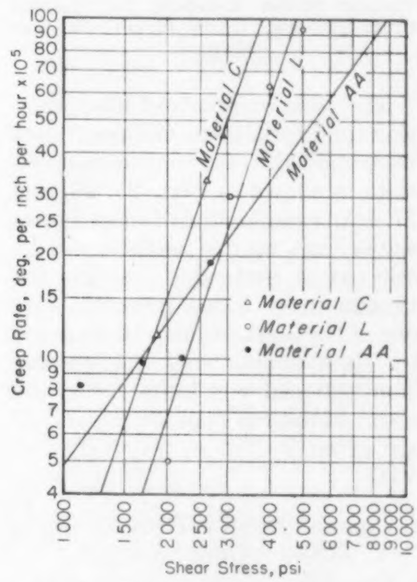

Fig. 25.—Comparison of Creep Rate-Static Torsion Stress Relations for Tubular Cross-Sections, Using Log-Log Method.

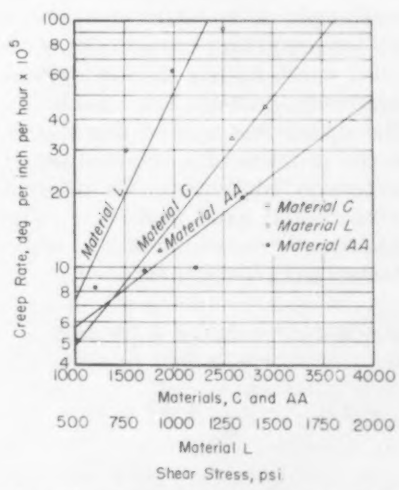

Fig. 26.—Comparison of Creep Rate-Static Torsion Stress Relations for Tubular Cross-Sections, Using Log Method.

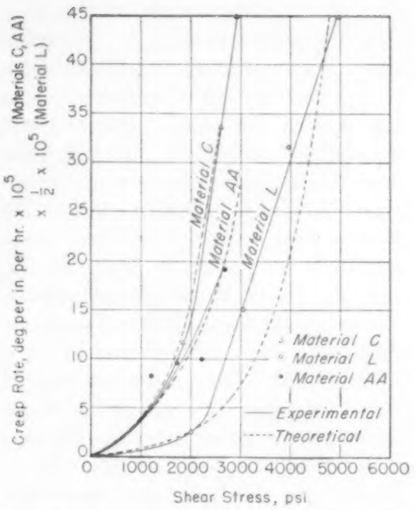

Fig. 27.—Comparison of Creep Rate-Static Torsion Stress Relations for Tubular Cross-Sections, Using Hyperbolic Sine Method.

The three methods of interpretation used for the tension-creep data were applied to the torsion-creep results as shown in Figs. 25, 26, and 27. An examination of these figures shows that no one method can be selected as preferable. As for the tension-creep data, however, any one of the methods may be assumed to approximate the test results. The material constants using the assumed lines in Figs. 25, 26, and 27 are given in Tables VI, VII, and VIII.

Correlation of Torsion and Tension-Creep Values

For design purposes it would be highly desirable if creep values for various types of stress could be determined from the tension-creep constants. A distortion energy theory for predicting creep under combined stresses using the log-log tension-creep constants is available (**2**). The author has applied this theory to the problem of a tube subjected to torsion combined with internal pressure and axial loads (**2**). The axial and circumferential creep stresses were found to be

$$C_a = B/2(S_a^2 - S_aS_c + S_c^2 + 3S_s^2)^{\frac{n-1}{2}} (2S_a - S_c) \ldots\ldots\ldots\ldots (4)$$

$$C_c = 3B(S_a^2 - S_aS_c + S_c^2 + 3S_s^2)^{\frac{n-1}{2}} S_s \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

TABLE XI.—COMPARISON OF THEORETICAL AND EXPERIMENTAL CREEP VALUES IN TORSION.

Material	Specimen	Shear Stress, psi.	Creep Rate, deg. per in. per hr. × 10⁵		Difference in Creep at 1000 hr. Between Experimental and Theoretical, per cent
			Experimental	Theoretical	
L....	No. 3a	2020	5.0	12.5	8
	No. 1	3050	30.0	30.6	9
	No. 4	3960	63.3	57.0	1
	No. 2	5000	93.3	92.8	0
C....	No. 5	1850	11.7	16.6[a]	3
	No. 6	2590	33.5	25.3[a]	4
	No. 7	2920	45.0	29.0[a]	2
AA....	No. 3	1200	8.3	3.4	8
	No. 4	1700	9.7	4.6	5
	No. 5	2220	10.0	5.9	3
	No. 6	2680	19.2	7.1	8

[a] Values obtained using B and n values for round tension creep specimens.

where

S_a = the axial stress,
S_c = the circumferential stress,
S_s = the torsional stress,
B, n = the tension log-log creep-stress constants,
C_a = the axial creep rate, and
C_c = the circumferential creep rate.

For pure torsion $C_a = 0$ in Eq. 4, and the circumferential creep rate C_c is

$$C_c = 3^{\frac{n+1}{2}} BS_s^n \ldots\ldots\ldots (6)$$

The creep rate C_c in Eq. 6 is expressed in radians per inch of the length. Using the B and n values from the tension-creep tests, the predicted torsion-creep rates, as obtained by Eq. 6, are given in Table XI. Using these creep rates and correcting for the initial creep, the predicted creep angle of twist for each stress and material is obtained. The actual values of the creep angles of twist are also calculated for purposes of comparison with the predicted theoretical values. (See Table XI.) In view of the many assumptions and the fact that this is a new field of study, the agreement between tests and theory is considered adequate.

Conclusions

1. The values obtained for the strength, stiffness, and ductility of the three laminates tested show that the relative values of these properties in tension are not the same as for torsion and compression.

2. The relative creep resistance for the three laminates was found to be different in tension than in torsion.

3. Three methods of interpretation for selection of design stresses considering creep were used. Any one of these methods of interpretation may be used approximately to represent the creep rate-stress variation. There are not sufficient experimental results, however, to arrive at a definite conclusion.

4. An approximate prediction of torsion-creep deformations based on the log-log tension-creep constants is given.

Acknowledgments:

The tests reported in this paper were made in the Creep Laboratory, Department of Engineering Mechanics, The Pennsylvania State College. The Synthane Corp. supplied the material for making the tests. Hiram Albala, Research Assistant in the Engineering Experiment Station, recorded the test data and plotted the graphs.

References

(**1**) W. N. Findley, "Creep Characteristics of Plastics," Symposium on Plastics, pp. 118–134, Am. Soc. Testing Mats. (1939). (Symposium issued as separate publication.)

(**2**) J. Marin, "Mechanical Properties of Materials and Design," McGraw-Hill Book Co., New York, N. Y. (1942).

(**3**) A. Nadai, "The Influence of Time Upon Creep—The Hyperbolic Sine Creep Law," Stephen Timoshenko Anniversary Volume, Macmillan Co., New York, N. Y., p. 155 (1938).

(**4**) A. Nadai and P. G. McVetty, "Hyperbolic Sine Chart for Estimating Working Stresses of Alloys at Elevated Temperatures," *Proceedings*, Am. Soc. Testing Mats., Vol. 43, p. 735 (1943).

APPENDIX I

Hyperbolic Sine Method for Interpretation of Creep Data

The log-log and log methods of interpretation are ones that usually have been used for interpretation of creep-test data on metals. A newer method, which promises to give a better fit to creep-test data on metals, is the hyperbolic sine method proposed by Nadai (4). By this method the creep rate-stress relation is assumed to be

$$C = C_1 \sinh (S/S_1) \qquad (7)$$

where C_1 and S_1 are experimental constants for a particular material.

It is not possible to determine C_1 and S_1 by using a direct procedure as in the log-log and semi-log methods because in Eq. 7, S_1 appears in the hyperbolic sine term. However, the following indirect method for finding S_1 can be used.

If S', C', and S'', C'' represent the stress and creep-rate values that correspond to one of the lowest and highest stress test points, then in order for the curve represented by Eq. 7 to pass through these points,

$$C' = C_1 \sinh (S'/S_1) \qquad (8)$$

and

$$C'' = C_1 \sinh (S''/S_1) \qquad (9)$$

Dividing Eq. 9 by Eq. 8,

$$R_c = C''/C' = \frac{\sinh (S''/S_1)}{\sinh (S'/S_1)} \qquad (10)$$

Equation 10 defines the value of the constant S_1, since all other quantities in Eq. 10 are known. However, since S_1 cannot be evaluated directly from Eq. 10 the following method will be used:

1. Select a series of values of S'' and S' covering the range of stress values in the test.

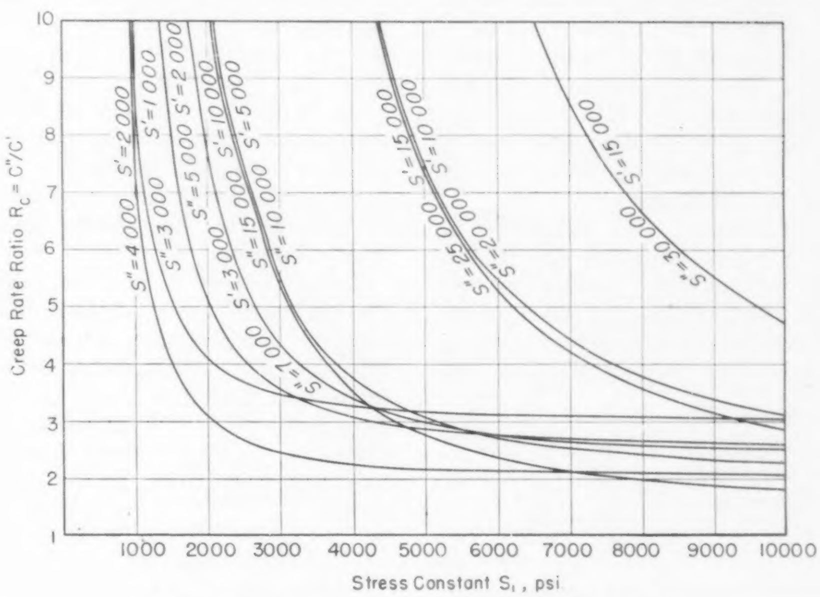

Fig. 28.—Graph for Determination of Stress Constant S_1.

2. Substitute each set of S'' and S' values in Eq. 10 and obtain a relation between the creep ratio R_c and the stress constant S_1.
3. Plot the relation obtained in item 2 as shown in Fig. 28.
4. Repeat the above for other sets of S'' and S' values and plot as shown in Fig. 28.
5. The value of S_1 corresponding to the S'' and S' values can be obtained directly from the graph when the value of $R_c = C''/C'$ is known for a particular material. With S_1 known, the value of C_1 can be calculated by using Eq. 8. The units of S_1 and C_1 correspond to those used for S and C, respectively.

In applying the procedure for determining S_1 it should be noted that Eq. 7 is asymptotic to the straight lines $R_c = S''/S'$ and $S_1 = 0$. This means that the minimum possible value of R_c is S''/S'. But since $R_c = C''/C'$, it is necessary in selecting the test points that $C''/C' > S''/S'$.

DISCUSSION

Mr. E. P. Popov[1] (*presented in written form*).—Mr. Marin has presented some interesting data on the physical properties of cloth laminates. Besides presenting such data, he attempted to obtain certain theoretical correlations.

Creep phenomena even for the most homogeneous materials are very complex, and for the plastics reported, it is undoubtedly even more so. I question in principle the validity of application of the distortion energy theory to materials that do not possess equal moduli of elasticity in tension and compression. The above theory tacitly assumes their equality and a constant Poisson's ratio. Moreover, the materials investigated even exhibit different properties in identical tension tests depending on their cross-section, as is shown in Table V.

Then as a matter of detail, I note that the author in attempting to correlate creep rates in torsion to those of tension in Table XI properly chose to use the data from similar tubular tension specimens in two cases, yet used data from round specimens in one. The latter seems unwarranted. The experimental constant B, as we see from Table VI for the C material, is 6.28×10^{-11} in one case and 9.55×10^{-16} in the other. The writer would like to know the reason for such a choice.

For the sake of completeness of the paper, I believe it would be well to include the temperature and humidity at which the tests were performed.

Mr. P. G. McVetty[2] (*presented in written form*).—Mr. Marin has given us a method for determining the constants in the hyperbolic sine relation between stress and creep rate. For those who may wish to try other methods which have been proposed, reference is made to a similar procedure sug-

[1] Assistant Professor of Civil Engineering, University of California, Berkeley, Calif.

[2] Mechanical Engineer, Research Labs., Westinghouse Electric Corp., East Pittsburgh, Pa.

gested in 1943.[3] These methods show that it is not difficult to apply the hyperbolic sine relation when creep rates are known for two or more stresses at the same temperature. The advantages of the hyperbolic sine over the more commonly used straight-line log-log plot are clearly indicated in the 1943 A.S.M.E. paper.[3]

CHAIRMAN J. H. ADAMS.[4]—One thing which impresses me in this sort of activity, having worked with plastics game for a long time, is that we continually battle to simplify the testing of these materials. We continually try to find shortcuts to knowledge.

I wonder whether we do not thereby, to a considerable extent, fail to improve our knowledge. That is, if we should recognize some of the complexities of really understanding materials, and try to learn the various things that we should know about them, and apply that knowledge, we should make greater progress.

In the paper, it is shown that these materials have their individual virtues. None of them has all the virtues—each has its own particular ones—and that, I think, is a very important point to remember in materials, that one cannot look at one thing and know all about materials.

MR. JOSEPH MARIN (*author's closure by letter*).—The author agrees with Mr. Popov that the distortion energy theory does not strictly apply. This is not because of differences in modulus of elasticity as stated by Mr. Popov, but it is due to the differences in compression and tension yield strengths of the plastics. As a matter of fact, the moduli of elasticity in tension and compression for the plastics tested are nearly equal. The reason for using the theory is that it is the only one available and the application of this theory represents at least an attempt to interpret the test results. The tests were made at a temperature of 77 ± 5 F. and a humidity of 50 ± 2 per cent.

[3] P. G. McVetty, "Creep of Metals at Elevated Temperatures—The Hyperbolic Sine Relation between Stress and Creep Rate," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 65, pp. 761–769 (1943).

[4] Bakelite Corp., Bound Brook, N. J.

Material Purchase Specifications

By S. B. Ashkinazy[1]

RECENT articles and technical papers on the theories, philosophies, and need for material purchase specifications have presented many conflicting views on this important subject. There are some individuals, found mainly among suppliers of certain groups of materials, who feel that purchase specifications are unnecessary, impractical, and detrimental to the interests of both the consumer and the producer; there are others who firmly believe that purchase specifications are necessary, but cannot get together as to the type of specification that should be employed, namely, composition, properties, or performance type, or any combination of these. It is the author's desire to record his experiences and those of the company he represents, thereby helping to crystallize thinking along certain lines which have heretofore not been brought out.

The main function of any purchase specification is to inform the supplier exactly what is required, in a manner that puts the least amount of restriction on the supplier and yet assures the buyer that the quality and *characteristics* of the product will not vary with each purchase. The assurance that the characteristics of the material will be the same each time is of great importance, as will be shown later, and constitutes the guiding factor as to which type of specification should be employed for a given group of materials.

Materials purchased to specifications must in addition be studied thoroughly in the laboratory and in service to determine all of their basic properties and characteristics so that intelligent application can be made. Thus we get to know the various physical properties of the materials, such as coefficient of expansion, thermal conductivity, electrical conductivity, specific heat, melting point, and many others; we learn their characteristics, their behavior in various corrosive media, their fabricating properties in relation to machining, stamping, forming, welding, brazing, and soldering, and many other pertinent facts. Such fundamental data have been compiled for a good many materials, and are constantly being added to. At Sperry, such data are made available to our engineers and other personnel in the form of Material Standards, which system has been described by the author in the article "Materials Standardization" (**21**).[2] The important thing, from the specification standpoint, however, is that once the engineer has learned to utilize a certain property or characteristic of a material, he must be assured of getting that same property or characteristic at all times.

COMPOSITION TYPE SPECIFICATION

The composition type specification ties down the exact chemical composition or makeup of a material. This type of specification is best suited for the specifying of metals and alloys. The manufacture of the more common metals and their alloys is now well established, and manufacturers make routine chemical analysis tests for each batch melted. As a result, nearly all metallic materials are supplied under some form of composition specification. The buyer is thus assured of the same basic characteristics of the material each time.

NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Material and Process Standards Supervisor, Sperry Gyroscope Co., Inc., Great Neck, N. Y.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

Typical examples of this type of specification are A.S.T.M. Specifications A 108 – 46,[3] B 92 – 45,[4] and many others.

The composition type specification does not lend itself to the specifying of most nonmetallic materials, including finishing materials such as paints, enamels, varnishes, and lacquers. By the nature of these materials, the exact ingredients and the percentage of each may vary from supplier to supplier and yet be entirely interchangeable. Furthermore, most purchasers are not qualified to prescribe the exact chemical composition or makeup of this type of material, and the manufacturers are reluctant to divulge their composition formulas to buyers for fear that other suppliers may duplicate their products. For these materials, other types of specifications must be employed.

Properties Type Specification

The properties type specification, often referred to erroneously as a performance type specification, ties down the physical, chemical, electrical, and other properties of the material that are capable of being measured in the laboratory by standard methods of test. The composition, makeup, or chemical constituents of the material are not specified. This is a very desirable type of specification but unfortunately cannot be used by itself if assurance of receiving the same product each time is to be had.

As pointed out by Gerald Reinsmith (25), one of the important advantages claimed for this type of specification is the ease with which changes from one material to another may be made in times of critical shortages. This is the very reason why it is highly dangerous to utilize the properties type specification by itself. In our own company, and in most others (and the same might be said of any A.S.T.M. purchase specification), when a material is standardized for general use, all of the applications to which that material may be applied are not known. It is therefore impossible to write a properties type specification that can foretell and tie down every requirement to which a general-use material may be put. A purchase specification may define very clearly the scope and purpose for which the material is intended, but that is not going to stop an engineer from trying it out and adopting it for use in applications for which the material was not specifically intended. If the supplier is permitted to change the basic characteristics of the material as long as he meets the requirements and intended purpose of the material as set forth in the specification, he may certainly overlook the requirements of the "nonintended" applications. The engineer who applies materials to unorthodox uses should not be considered a heretic but rather should be commended for his ingenuity in solving a difficult design problem. Once he specifies that material on the drawing, he is entitled to the same protection from the purchase specification as the orthodox user, namely, that the material will function in the same manner as when he first tried it out in his product and found it to do the job.

An interesting illustration of this point was brought out during the war when a supplier of a certain general-purpose lacquer changed ingredients which resulted in the fogging of optical lenses when applied to adjacent parts. The supplier had complied with all the chemical, physical, and other requirements of the specification, but naturally did not know of this special requirement. The engineer had originally tried out the several prewar lacquers approved in the specification and found that they gave him no trouble in regard to fogging. He therefore adhered to that specification.

Another advantage claimed for the properties type specification is that it permits the manufacturer to retain his initiative in the development of his own engineering and manufacturing skills, and be free to consider improvement of his product to the benefit of the purchaser. It should be pointed out that the manufacturer is in a position to do all that regardless of the type of specification he is called upon to work to. The specifications engineer would not be doing his job were he not on the constant lookout for new and improved products, and for ways and means of improving his specifications. The only thing he insists on, however, is that, if there is any change or improvement to be made, he be told about it first and be given the opportunity to try it out and determine what effect it may have on existing products. One supplier found it convenient to ship a higher grade of electrical silicon steel whenever he ran out of the grade ordered without notifying the customer. It so happened that the material was intended for a product that could not tolerate the lower core loss and higher permeability of this higher grade of electrical steel. It was a matter of calibration. The substitution of material had not been discovered until thousands of laminations had been punched, stacked, and assembled into the instruments which, of course, did not function properly.

An example of the pure properties type specification is A.S.T.M. Specification D 735 – 43 T[5] on Rubber Compounds. By not mentioning the basic chemical constituents of the material, such as chloroprene, Buna S, Buna N, butyl rubber, thiokol, and others, this specification permits under any one compound the supplying of more than one type of rubber, with accompanying differences in certain basic properties, depending on the type that is supplied on any one purchase.

This particular so-called classified type of properties specification is especially bad. It permits an endless number of combinations of properties without assuring the buyer that the particular combination selected can be procured or is even capable of being produced. It is possible to select a compound such as RS 915 and add a suffix number (-5), making it RS 915-5 and hope to be able to procure this rubber compound of 90 durometer, 1500 psi. tensile strength, and 500 per cent minimum elongation. To go a step further, a suffix FF can likewise be added, requiring the compound to pass the low-temperature brittleness test at −70 F., even though the purchaser may not have the slightest idea whether such a compound can be concocted.

[3] Standard Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting, 1946 Book of A.S.T.M. Standards, Part IA.

[4] Standard Specifications for Magnesium Ingot and Stick for Remelting, *Ibid.*, Part IB, p. 190.

[5] Tentative Specifications for Rubber and Synthetic Rubber Compounds for Automotive and Aeronautical Applications, *Ibid.*, Part IIIB.

The question then is how can the properties type specification be modified to afford assurance of the same product with each purchase. There are three ways in which this can be accomplished, depending on the group of materials involved. The first is to use it in conjunction with the composition type specification, as for wrought metals, in order to control the condition and temper of the metal. Alloys of the same composition can be manufactured and treated in a number of ways to produce various ranges of mechanical properties. Typical examples are A.S.T.M. Specifications B 211 - 46 T,[6] B 91 - 45 T,[7] and many others.

The second way to utilize the properties type specification is to specify, in addition, the basic chemical constituents of the material without stating the exact quantities or percentages. This form of specification is applicable to a good many nonmetallic materials, especially the plastics and many electrical insulating materials. By specifying that a certain plastic shall be a melamine-formaldehyde compound with an alpha cellulose filler and shall possess certain physical, chemical, and electrical properties, assurance can be had that a material of the same characteristics will be supplied each time. The specifying of the melamine-formaldehyde resin and alpha cellulose filler carries with it certain inherent properties and characteristics not directly specified in the specification. The properties type specification in which the basic chemical constituents are specified is being employed with success by A.S.T.M. Committees D-20 on Plastics and D-9 on Electrical Insulating Materials. Typical examples are A.S.T.M. Specifications D 700 - 45 T,[8] D 701 - 46 T,[9] D 702 - 46,[10] D 703 - 44 T,[11] D 704 - 44 T,[12] and many others.

[6] Tentative Specifications for Aluminum and Aluminum-Alloy Bars, Rods, and Wire, *Ibid.*, Part IB, p. 560.

[7] Tentative Specifications for Magnesium-Base Alloy Forgings, *Ibid.*, p. 604.

[8] Tentative Specifications for Phenolic Molding Compounds, *Ibid.*, Part IIIB.

[9] Tentative Specifications for Cellulose Nitrate (Pyroxylin) Plastic Sheets, Rods, and Tubes, *Ibid.*

[10] Standard Specifications for Cast Methacrylate Plastic Sheets, Rods, Tubes, and Shapes, *Ibid.*

[11] Tentative Specifications for Polystyrene Molding Compounds, *Ibid.*

[12] Tentative Specifications for Melamine-Formaldehyde Molding Compounds, *Ibid.*

The third way to utilize the properties type specification and have the assurance of obtaining the same material each time is to record, in addition, the manufacturers' tested and approved products in the specification and stipulate that these shall not be changed without the consent of the buyer. This, in effect, constitutes brand name buying, but goes a step further in that it still requires the manufacturer to meet all of the property requirements listed in the specification. This form of specification must be resorted to for materials such as oils, lubricants, adhesives, sealing compounds, paints, and others which cannot be completely described by any other form of specification. A typical specification of this type is illustrated in the author's article "Applied Finishes Standardization" (**24**).

In specifying the manufacturers and their approved products directly in the specification, one may ask what deleterious effect does this disclosure have on vendor-buyer relationship. The answer is, absolutely none when the top few suppliers have been selected in strict accordance with the results obtained from laboratory and field tests.

There are some manufacturers, however, who advocate brand name buying rather than specification buying for these materials. In one respect, the manufacturers cannot be blamed for this attitude as most of the specifications they come in contact with are properties type specifications containing minimum limits only, thus permitting the purchasing department to buy on the open market. This, argues Mr. Voshell (**27**), usually brings about the purchase of the most cheaply constructed product that will just pass the minimum limits of the specification. This argument, however, does not hold true for the specification which, in addition to minimum properties limits, records the top few only of the products tested, even though a dozen other products may have passed the minimum requirements of the specification.

In every other respect, brand name buying works to the detriment of both the consumer and supplier. Brand name buying leads to a single source of supply which is undesirable to the purchaser from the standpoint of cost and delivery, especially in small quantity buying. It also works to the detriment of the supplier for just as one engineer can specify one brand name, another can specify another brand name, prohibiting the first supplier from getting consideration in the second case and *vice versa*. It thus prevents another manufacturer from supplying a better product at lower cost, or from translating his quality and efficiency of manufacture into sales.

The specifying of brand names on drawings leads to antiquated materials or to the need for changing thousands of drawings when new and better materials become available. It leads to poor buying economy and duplication of stock, as several brand names of the same material may be purchased and stocked separately whereas they can be lumped together in specification buying. Engineers and shop foremen in specifying brand names may be influenced by friendship for certain suppliers, by hearsay, and other personal preferences. The recommendations made *via* the purchase specification are based on careful and thorough considerations which are supported by laboratory tests and unbiased judgment. Consideration is given to final over-all cost rather than initial cost.

The advocates of brand name buying urge the purchaser to rely on the integrity and reputation of the supplier and on the quality, stability, and uniformity of his product. That is all well and good, but when things go wrong and the material is found defective, the supplier will profess his sorrow and offer to replace the substandard material. Replacing the material will not compensate for loss in machining and assembly time, or for the failure of the product in service which may even involve the loss of life and limb. Specifications containing physical and chemical properties which can be checked in the laboratory are absolutely essential for determining uniformity and continuity of high quality of the material.

Performance Type Specification

In the true performance type specification, the purchaser en-

deavors to obtain a warranty of future performance in service. The purchaser, either alone or with the supplier's engineers, determines the desired standards of performance for his particular equipment and then requires the supplier to meet these standards.

This type of specification lends itself mostly to materials such as cutting oils, shop equipment lubricants, stripping compounds, and others. In cutting oils, for example, the supplier might be asked to furnish an oil for a turret lathe used to machine aluminum and magnesium. The performance standards of the cutting oil are based on rate of production, surface finish of parts, tool wear, maintenance, power, and cost. These performance requirements cannot be measured by standard laboratory tests. As long as the oil performs satisfactorily in the machine, it will continue to be used, but if the performance deteriorates, the supplier's engineers are called in and an attempt is made to reestablish the high performance. If that does not work, another oil is substituted.

The use of the performance type specification for most engineering materials is still a thing of the future. Very little success has been had in the attempt to correlate standard laboratory tests with service performance. With no laboratory tests, the suitability, uniformity, and quality of the material cannot be determined in advance. This prohibits the use of the performance type specification except where it is practical to call in the supplier's engineers on every application, present the necessary performance requirements, and have the suppliers recommend products which will meet these requirements. In a company like Sperry where hundreds of products are engineered all year long, it would require practically the full time of one or two of each supplier's engineers to render this sort of service.

Conclusion

In conclusion, the author would like to stress the following points:

1. Purchase specifications are absolutely essential for the procurement of materials and for the maintenance of their uniformity and quality.

2. Different groups of materials require different types of specifications.

3. The assurance that the characteristics of the material will be the same with each purchase should constitute the guiding principle as to which type of specification should be employed for a given material.

4. Nationally issued specifications are of greater value from the standpoint of availability, uniformity, and low cost of materials, than the ones set up by the individual purchasers.

5. More A.S.T.M. purchase specifications are needed. In this respect, the A.S.T.M. should not wait for the trade organizations to take the initiative.

6. Quoting H. H. Morgan (**16**), "when we speak of the general benefits which accrue through the use of specifications, we mean *good* specifications."

A number of fine treatises on the preparation and construction of specifications are listed in the references.

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ASTM Bulletin

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PHILADELPHIA 3, PENNA.

Purchase Specifications

THERE is probably no other medium more appropriate for disseminating ideas and discussion on the significance of materials specifications than the ASTM BULLETIN. We are pleased to present another interesting paper in this issue by S. B. Ashkinazy who has prepared a number of significant articles on the subject of standards and specifications. We commend to all members of A.S.T.M. the reading of this relatively short article and point to the conclusion which stresses the importance of purchase specifications, the necessity of having different types of such standards, the significance of nationally issued specifications, and his challenge that more A.S.T.M. purchase specifications are needed.

We are quite ready to publish articles in the BULLETIN discussing this important subject of specifications even though they may present views quite contrary to accepted practice, possibly finding that a great deal is wrong with some of our present specifications. Constructive criticism should result in making A.S.T.M.'s activities of more value.

1947 Nominating Committee

IN ACCORDANCE with the By-laws, providing that the Board of Directors at its October quarterly meeting shall select a nominating committee for officers, the Board has considered the report of the tellers, Edgar K. Spring, Chief Metallurgist, Henry Disston and Sons, Inc., and Tinius Olsen, 2d, Assistant Treasurer and Sales Engineer, Tinius Olsen Testing Machine Co., on the recommendation of members for appointees on the nominating committee and selected the following committee and alternates:

MEMBERS

R. W. Steigerwalt, Carnegie-Illinois Steel Corp.
J. J. Paine, City of Pittsburgh
R. E. Roscoe, Bessemer Limestone and Cement Co.
G. H. Harnden, General Electric Co.
D. E. Parsons, National Bureau of Standards
J. J. Kanter, Crane Co.

RESPECTIVE ALTERNATES

H. R. Redington, National Tube Co.
H. H. Morgan, Robert W. Hunt Co.
D. S. MacBride, Hercules Cement Corp.
N. L. Mochel, Westinghouse Electric Corp.
K. B. Woods, Purdue University
W. H. Finkeldey, Singmaster & Breyer

The three immediate past-presidents, J. R. Townsend, H. J. Ball, and Dean Harvey, serve as *ex-officio* members of the 1947 Nominating Committee. The committee will meet in March and make nominations for each office—president, vice-president, and five Members of the Board of Directors. The selections by the nominating committee will be announced to the members in the ASTM BULLETIN prior to transmission of official ballots.

1946 Year Book Issued

THE 1946 A.S.T.M. Year Book giving a complete list of the Society membership, as of October, and aggregating over 500 pages has been distributed to all members who have requested a copy. This book is sent only to members on request and it is intended for use in connection with the activities of the Society. While the current edition follows in general the style and arrangement used for previous Year Books, a more attractive cover is being used and throughout the publication there are a number of changes which are intended to make the book of still more utility. Following a general information section which gives certain data about the Society not published elsewhere including two tables of dates, places, and subjects covered at national A.S.T.M. meetings since 1930, there is a list of the Honorary and Sustaining members and then a complete list of members in alphabetical sequence. The Geographical list follows and then begins a list of technical and other committees and their personnel. This section of the Year Book comprises some 228 pages. This section in itself indicates the extent of the Society's committee structure. The Year Book is complete with information on past officers, By-laws and regulations governing the Board of Directors and technical committees, recommendations on the form and style of Standards, and finally membership application blanks are bound in the back of the book for the convenience of the members.

Offers of Papers for 1947

THE Administrative Committee on Papers and Publications will meet early in February to consider the papers to be published by the Society in 1947 and to develop the program of the 1947 Annual Meeting to be held in Atlantic City, N. J., June 16–20. All those who have in mind offering papers for presentation at the Annual Meeting and publication by the Society should send these offers to Society Headquarters no later than February 1.

All offers should be accompanied by a summary which should make clear the intended scope of the paper and indicate features that, in the opinion of the author, will justify its inclusion in the Annual Meeting program and publication by the Society. Suitable blanks to be used in transmitting the desired information are being distributed to all A.S.T.M. members. Additional blanks and blanks for nonmember use will be sent promptly on request.

Additional Building Fund Subscriptions

In response to a report on the A.S.T.M. Headquarters sent to those members who had not previously contributed to the Society Headquarters Building Fund and which pointed to a deficit in the fund of about $30,000 and explained that sharp increases in building and labor costs and related items had caused this situation, a number of additional contributions to the fund have been received from companies and individuals. The names of the contributors appear below.

The Board's communication pointed out that to make changes in the plans which had been agreed upon and which were rapidly being put into effect, would have created an extremely undesirable situation and, therefore, a decision was reached to proceed in line with the general outline with the hope that additional contributions to the Building Fund might go a long way in achieving what the Board wishes, namely, that the Building shall be free from any encumbrance as soon as possible.

It is planned to have the Building formally dedicated with appropriate ceremonies on Wednesday, February 26, during A.S.T.M. Committee Week. In connection with these ceremonies a special dinner is being arranged for that evening to be held probably at the Benjamin Franklin Hotel, but further announcement will be made concerning this. Meanwhile, all members who may be in Philadelphia are cordially invited to visit the Headquarters Building.

Supplementary List of Company Subscriptions to A.S.T.M. Building Fund up to November 19, 1946*

Ambursen Engineering Corp.
Bell & Howell Co.
Black & Veatch
Brown & Sharpe Mfg. Co.
Cantor Greenspan Co., Inc.
Commercial Testing & Engineering Co.
Eastern Malleable Iron Co., The
Hanks, Abbott A., Inc.
Harley-Davidson Motor Co.
Kelley Island Lime & Transport Co.
Landers Corp., The
Lavin, R., & Sons
Locomotive Finished Material Co., The
Long, Chas. R., Jr., Co.
Madison-Kipp Corp.
Nashua Gummed & Coated Paper Co.
Nix, Karl W. V., Co.
North American Cement Corp.
Patton Clay Mfg. Co.
Pennsylvania Water & Power Co.
Smith-Emery Co.
Westcott & Mapes, Inc.

Supplementary List of Individual Subscriptions to A.S.T.M. Building Fund up to November 19, 1946*

Bacon, Chas. V.
Bodell, Philip T.
Brust, A. W.
Camps, E. V.
Cedergren, H.
Clark, M. M.
Crepps, Ray B.
Davis, F. W.
Dantsizen, Christian
Eavenson, Howard N.
Edgerton, C. T.
Edwards, Warrick R.
Eleta, Fernando
Eynon, H. B.
Floor, Walter
French, Dudley
Fridstein, Meyer
Gammel, Walter A.
Graybill, L. A.
Greenall, Chas. H.
Harrison, Jos. W. E.
Harvey, Dean
Heimbucher, Walter
Hewett, C. M.
Holler, Albert C.
Jameson, A. H.
Kaufman, C. E.
Kelley, Earl F.
Kelly, Clyde
Lake, Gerard K.
Leschen, A.
Lovell, Wheeler G.
Luton, R. E.
Miesenhelder, P. D.
Milly, R. F.
Murphy, Paul S.
Murray, W. M.
Partridge, Everett P.
Peterson, Phil. R.
Quick, G. Willard
Reynolds, Stanley C.
Richart, F. E.
Rowan, Wm. H.
Russell, Earl A.
Russman, Arthur
Rapp, G. M.
Richardson, G. S.
Schofield, Roger S.
Sedwick, T. D.
Shuman, E. C.
Simonds, Herbert A.
Stanton, Frank
Stiehler, Robt. D.
Suhrie, Geo.
Sullivan, Charles L., Jr.
Templin, R. L.
Thomas, George G.
Vassar, H. S.
Voss, Walter C.
Wertz, F. A.
Wickersham, John H.
Williams, Robt. S.
Wilson, Geo. A.
Withrow, James R.
Wood, Alan

* The December, 1945, Bulletin included a complete list of Company and Individual subscribers up to November 30, 1945. The names of those who subscribed to the fund between November 30, 1945, and late summer of 1946 have appeared in various issues of the Bulletin in that period.

New Trim Size for Bulletin

During the war period when paper shortages were imminent and actual, a number of modifications in the ASTM Bulletin were made to conserve paper; in particular, the weight of both cover and inside paper stock was considerably lightened. Because the amount of paper used by the Bulletin was not of a sufficient tonnage that a change in the trim size would have effected worth-while saving in paper, no dimensional changes were made, even though a great many journals with a much larger circulation and more frequent appearance did reduce their trim size. Now, however, there are certain good reasons why, beginning with the January Bulletin and continuing indefinitely, it is hoped, the trim size will be reduced from the present $8\frac{3}{4}$ by $11\frac{1}{2}$ in. to the $8\frac{1}{4}$ by $11\frac{1}{4}$ in. trim size. The type page will remain the same, namely 7 by 10 in. The National Industrial Advertisers' Association which a few years back had urged journals to use the size adopted for the Bulletin now recommends the use of the $8\frac{1}{4}$ by $11\frac{1}{4}$ in. dimensions, and with a number of journals accepting this size there is hope that most of the technical and business journals will fall in line. The new size will enable our printer who handles a number of engineering society publications to schedule operations, purchase certain size paper and do other things more efficiently which should expedite publication.

Aside from the break which will occur in the permanent binders of those who bind up two or three years' copies of the Bulletin in one binder, the only group to be affected to any degree will be those advertisers who occasionally use full bleed pages.

Experts Disagree

Experts always seem to disagree—whether they be paint test engineers, surgeons, or lawyers. Disagreement is a healthy sign for it indicates that people are thinking. Most disagreement stems from honest differences of opinion. Opinions differ because there is insufficient factual evidence to support one sweeping conclusion. We need more facts in order to eliminate some of the controversial opinions.

—Part of Discussion by Messrs. Lutz and Lewis of paper by A. C. Elm on "Principle of Immersion and Humidity Testing of Metals Protective Paints," in October, 1946, ASTM Bulletin.

Work on 1946 Book of Standards Being Expedited; Numerous Other Publications Issued; Many More in Prospect

Work on the publication of the 1946 Book of A.S.T.M. Standards, which is to be issued in five parts, is being expedited in the hope that shortly after the new year distribution can start for one or two of the five Parts. As previously announced, the large increase in the number of specifications and tests and the great increase in the number of pages of material necessitated further expansion of the Book into five Parts, as compared with the three Parts of the 1944 Book.

A recent communication to all members covered various details about the new Book, and pointed out that if new instructions were necessary concerning the Supplements members wish to receive after January 1, 1947, A.S.T.M. Headquarters should be advised promptly. (A return card was sent for this purpose.) All members whose instructions have been on file for the previous 1944 Books and Supplements will receive those Parts of the 1946 Book which they normally would have received, but beginning with the 1947 Supplement and thereafter the new instructions will be in effect. In short, if a member received Part I of the 1944 Book, he will get Part IA, Metals, and Part IB, Non-Ferrous Metals, and similarly with Part III, a member who received former Part III will now receive Parts IIIA and IIIB. This applies to the 1946 Book, and *if no new instructions are received* for the 1947 and 1948 Supplements.

The Book is to be made up as follows:

Part IA—Ferrous Metals (Steel, Wrought Iron, Cast Iron, Magnetic Properties, Malleable-Iron Castings, Ferro-Alloys, Iron-Chromium Nickel and Related Alloys).
Part IB—Non-Ferrous Metals (Copper and Copper-Alloy Wires, Non-Ferrous Metals and Alloys, Light Metals, Electrodeposited Metallic Coatings, Metal Powders and Metal Powder Products, Electrical-Heating Alloys, Copper and Copper Alloys, and Die Cast Metals and Alloys).
Part II—Nonmetallic Materials—Constructional (Cement, Clay Pipe, Drain Tile, Lime, Concrete and Concrete Aggregates, Gypsum, Mortars for Unit Masonry, Concrete Pipe, Glass and Glass Products, Masonry Units, Natural Building Stones, Asbestos Cement Products, Thermal Insulating Materials, Paint, Varnish, Lacquer and Related Products, Soils, Wood, Road and Paving Materials, Naval Stores, Fire Tests, Refractories, Waterproofing and Roofing Materials).
Part IIIA—Nonmetallic Materials—Coal and Coke, Petroleum Products, Aromatic Hydrocarbons, Soaps, Water, Textiles, Gaseous Fuels.
Part IIIB—Nonmetallic Materials—Electrical Insulating Materials, Plastics, Rubber, Paper, Shipping Containers, Adhesives.

Sales prices for the new book have been announced, namely, \$8 to nonmembers for Parts IA, IB, IIIA, IIIB, and \$12 for Part II. Members are entitled to a 25 per cent discount on these prices for the extra copies they wish to order as distinct from the copy they will receive on their membership.

The new publication plan provides that after January 1 members who wish more than one Part of the Supplements will pay *annual* charges as follows: Any one Part, no charge; any two Parts, \$4; any three Parts, \$6; any four Parts, \$8; all five Parts, \$10.

While no specific date can be given for the distribution of any Parts of the Book, Part IB and Part II should be ready first, followed by the other three Parts. It is hoped that distribution of some of the Parts can begin early in January.

Special Compilations of Standards

While work is started immediately following the Annual Meeting on the preparation of new and revised standards and tentatives, very few of the publications can be completed until the fall since the Society's official letter ballot does not close until September. Frequently a technical committee responsible for one of the specal compilations of standards may wish to submit revisions or editorial changes for action by the Administrative Committee on Standards usually at its late August meeting. However, some of the compilations can be issued before the presses begin to roll on the forms for the Book of Standards and some that have been completed or will be issued shortly are noted here.

Standards on Electrodeposited Coatings:

A new compilation issued for the first time giving eleven standards—specifications, tests, recommended practices—covering various types of coatings on steel, certain non-ferrous metals and alloys, etc. Tests cover thickness of coatings, salt-spray testing, preparation of material and the like. 60 pages, list price, \$1.25; to A.S.T.M. members, 90 cents.

Standards on Cement:

This is the eighth edition of this publication sponsored by Committee C-1. Includes all A.S.T.M. specifications and tests pertaining to the various kinds of cement and gives other related information. 190 pages, \$2.00; to A.S.T.M. members, \$1.50.

Standards on Textile Materials:

This very extensive compilation aggregating 530 pages has some 86 standards covering a wide variety of textile products. This book includes considerable supplementary material and it finds widespread usage throughout the industry. List price, \$4.00; to A.S.T.M. members, \$3.00.

Paper and Paper Products:

This compilation sponsored by Committee D-6 has some 55 standards. The latest edition which is just becoming available has been greatly enlarged. It now aggregates about 250 pages. List price, \$2.00; to A.S.T.M. members, \$1.50.

Petroleum Products and Lubricants:

This is the oldest and most widely distributed of the special compilations issued annually since 1927. The current edition is considerably enlarged, with some 20 standards on aromatic hydrocarbons included for the first time. There are now some 99 methods, 28 specifications, and three sets of definitions of terms. 610 pages, list price, \$4.00; to A.S.T.M. members, \$3.00.

Other Technical Publications

The Society's 1946–1947 publication schedule includes more special symposiums and collections of papers and reports than ever before. Work is proceeding rapidly on a number of these with several to be issued in the period between December and February. As this BULLETIN goes to press three of the books have become available: (1) the Symposium on Atmospheric Exposure Tests of Non-Ferrous Metal; (2) the Symposium on Gas Turbine Materials with supplementary papers;

and (3) a significant technical paper dealing with "The Theoretical Basis of Adhesion," by Doctor W. A. Weyl.

The Symposium on Non-Ferrous Exposure Tests includes the several papers and discussion presented at the Spring Meeting of the Society in Pittsburgh. This should be of widespread interest to all metallurgists and other technical people in the non-ferrous field and, in fact, any one concerned with the use of non-ferrous metals should find the book of interest.

The Symposium on Materials for Gas Turbines, one of the first of its kind, is a very significant book providing for the first time in compact form a great wealth of information and data much of it developed during wartime, dealing with materials that have been so important in the perfection of equipment by the Armed Forces. There are eight technical papers with numerous illustrations and a great amount of tabular material. This is a very comprehensive publication. 200 pages, list price, $3.00; to A.S.T.M. members, $2.25.

Members' Order Blank

There has been distributed to each member of the Society a Members' Order Blank, by which he can procure copies of the publications that have been issued, and enter orders for those on which work is under way. This blank is found of direct service by many hundreds of the members in obtaining books which are available only on sale or for procuring copies in separate form of material which is reprinted from the *Proceedings*.

Important Note on Graphitization from Committee A-1

During the past two years or so, Committee A-1 on Steel, particularly in its Subcommittee XXII covering Valves, Flanges, Fittings, etc., for High Temperature Service, has discussed at length problems involved in the graphitization of pipe and tubing and other products, including castings, where the materials were used at elevated temperatures. The committee has been particularly concerned with the graphitization question, and the various suggestions for inhibiting it, as related to the steel specifications of A.S.T.M. As a direct result of the work, a tentative specification (A 280) covering a grade of chromium-molybdenum pipe has been issued, which for many applications is being used instead of the former carbon-molybdenum grade covered in the high-temperature pipe specification A 206, and also A 106. Somewhat related action was taken this year by incorporating a new grade of steel (WC 3) with a chromium-molybdenum composition in the specification for Alloy-Steel Castings for High Temperature Service, A 217.

The committee at its Buffalo meeting approved a suggestion that a descriptive note on graphitization be published in the ASTM Bulletin, this note to reflect the feelings of the committee on the problem. Mr. J. J. Kanter, Chairman of the Section on Castings for High Temperature Service, was asked to prepare a note in connection with the casting specification, and Mr. F. E. Foster a similar note on specification A 280 in his capacity as section chairman. Accordingly, the following note from Mr. Kanter is published, and it is expected to publish subsequently a note concerning the pipe specification.

* * * *

Graphitization and Castings:

A new grade steel has recently been adopted in A.S.T.M. Specification A 217 intended for pressure containing castings for applications in welded power piping systems. The new grade is designated WC 3 and its chemical and physical properties include the following:

Carbon	0.30 per cent max.
Chromium	0.40–0.70
Molybdenum	0.40–0.60
Tensile Strength, min.	70 000 psi.
Yield Point, min.	45 000 psi.
Elongation in 2 in., min. per cent	22 per cent
Reduction of Area	35 per cent min.

This steel has been standardized by Subcommittee XXII and approved by Committee A-1 for the purpose of either supplementing or taking the place of Grade WC 1 in certain of the types of applications where it has been used.

This material was adopted to provide an economical grade of cast steel of relatively high creep strength which will resist graphitization. Graphitization at the heat-affected zone of welds has been found to have a weakening effect on grade WC 1 material when it is used at high service temperatures for prolonged periods. Study of the characteristics of WC 3 has been slow since the development of graphitization is only apparent with long heating times. Grade WC 3, however, has shown under accelerated test at 1025 F. that it can be heated at least ten times as long as grade WC 1 under a given set of conditions before graphitization becomes apparent.

There is some feeling that grade WC 3 is still not the final composition for graphitization resistance and that perhaps still other grades should be standardized for that purpose. In the light of our present meager information on the phenomenon of graphitization it would seem highly inadvisable to apply this steel for long range service over 950 F. Comprehensive research is in progress on graphitization of cast steel and some of it is centered around grades of higher alloy content than WC 3, under test at 1100 F. It may be expected that in the future new standards will be developed for cast materials which will still further minimize the structural changes which tend to occur in steels which are heated to high temperatures for prolonged periods.

Concurrently with the action suggesting a note on graphitization in the Bulletin, the A.S.T.M. committee requested the Boiler Code Committee of the A.S.M.E. to expedite its activities in placing a top temperature limit on the use of grade WC 3 in specification A 217 and for the grade covered in the pipe specification A 280.

Textile Testing in Germany Discussed at Committee D-13 Meeting

An afternoon session devoted to a description of some of the principal testing techniques and instruments developed by the Germans highlighted the recent meeting in New York of A.S.T.M. Committee D-13. This division of the Society develops textile standard specifications, tolerances, methods of testing, and definitions and terms.

A three-part talk was given by Dr. Lyman Fourt, Research Associate, Milton Harris Associates; Richard T. Kropf, Director of Research, Belding Heminway Corticelli Co.; and Herbert F. Schiefer, Senior Physicist, National Bureau of Standards. These men were part of a team which investigated textile testing in Germany.

The key items in this field in

which the Germans had made much progress were highlighted. Among the instruments which were illustrated by lantern slides and the use of which was described were: tensile strength testers for single fibers, yarns, and fabrics; the magnetic strain gage; abrasion testers, flexure testers and instruments for measuring thermal insulation of fabrics.

The combined paper on this program will be published in the January issue of ASTM BULLETIN and reprints can be obtained from ASTM Headquarters at 50 cents per copy.

As is customary, during the three-day meetings of Committee D-13 the several subcommittees under whose direction the work of D-13 is conducted met and reported on work in progress; discussed and acted on proposed changes in standards; proposed new methods; and outlined new work to be undertaken.

So much interest was shown in the need for work in the field of knitted materials that steps were taken to organize a subcommittee in the field of knitted fabrics and hosiery.

In line with the Society's recently announced policy of actively engaging in work on standards for ultimate consumer goods Subcommittee A-6 on Household and Garment Fabrics is organizing to undertake work in this field.

The rapid rise in the demand for improving and maintaining quality in consumer goods is placing an increasing pressure upon testing laboratories everywhere to develop methods of testing and inspection which will accurately determine the relative quality of merchandise, and which will insure the maintenance of standards established for a given product.

The meetings of the committee on wear-testing and abrasion were largely attended and a special effort is being made to correlate laboratory tests with the results of actual wear. In connection with sampling for inspection and testing, one of the important, but less publicized developments of the war, is a sampling technique known as "sequential" sampling. The Quartermaster Corps Inspection Service applied sequential analysis on a large scale, and during the war it was considered to be such an important means of conserving manpower and equipment that dissemination of information concerning its use was restricted to personnel directly connected with planning and research in war production. At the meeting of Subcommittee B-2 on Nomenclature and Definitions, David H. Schwartz, of the Quartermaster Corps Inspection Service, described this new technique, and a discussion *pro* and *con* concerning its merits followed.

The extensive research which is being carried on in many directions is expected to shed new light on the philosophy behind the different properties and the behavior of textile fibers and textile materials. The net result will be greater variety of merchandise, engineered for specific end uses, improved quality and greater consumer satisfaction.

DISTRICT ACTIVITIES AND NOTES

New Charter and Manual for Districts Adopted by Board of Directors

AT ITS meeting on October 8, the Board of Directors of the Society formally adopted the new District Charter and Manual. These two documents were prepared by the Administrative Committee on District Activities as the result of nearly eighteen months of intensive study and consultation with the existing District Committees. It is anticipated that the activities of the several districts, as carried out in accordance with the provisions of the new Charter, will greatly augment the efforts of the District groups in advancing the aims and purposes of the Society in their geographic areas.

An important feature of the new District organization concerns several new designations or terms to be adopted, beginning January 1, 1947, when the Charter becomes effective. Geographic groups will be known as *Districts—ASTM Districts*. Instead of referring to the governing groups as District Committees, they will be known as *District Councils* and will be comprised of a chairman, one or more vice-chairmen, a secretary, and from ten to twenty-five *Counselors*, all of whom are considered as officers of the Districts.

It is intended that the provisions of the Charter will make for greater autonomy within the Districts. The Administrative Committee on District Activities has plans that will bring about a more effective exchange of promotional ideas than has existed in the past. Toward this end, group meetings of officers or representatives of the several Districts will be planned for either annual or spring meetings of the Society.

The newly formed New England District is now in effective operation and much credit for its work must be extended to District Chairman Sherman, Vice-Chairman Altieri, Secretary Clair and Program Chairman Voss. The first New England District Meeting held on Nov. 21 is covered elsewhere in this BULLETIN.

Plans are progressing toward the organization of a District comprising the members in the Washington-Baltimore area.

FOR THE ADMINISTRATIVE COMMITTEE,
C. H. FELLOWS, CHAIRMAN

District Tours Moffett Field

ON September 27, members of the Northern California District took part in a tour of the Ames Aeronautical Laboratory at Moffett Field, California. Members were conducted through wind tunnels, the flight research laboratory, and other points of interest in the laboratory, which is one of the largest and most modern installations of its kind in the world.

Following dinner at the field cafeteria, there was a discussion of equipment in the laboratory, and some of the problems of the application of electrical power to aeronautical research.

Interesting District Meetings Scheduled

Sessions in Pittsburgh December 2; New York December 12; Chicago January 7, 1947; Philadelphia January 23

SUBJECTS to be covered in meetings being arranged by various districts, to be held in the next few weeks, include Progress in Rubber, Testing Materials with the Atomic Bomb, The Future of Atomic Energy, and Gas Turbine Materials and the Future of the Gas Turbine.

Pittsburgh and Chicago:

At meetings scheduled in Pittsburgh, Mellon Institute Auditorium, Monday, December 2, and in Chicago in the Auditorium of the Engineering Building on January 7, 1947, President Arthur W. Carpenter, Manager of Testing Laboratories, The B. F. Goodrich Co., Akron, Ohio, will deliver his address on Progress in Rubber and H. N. Stevens, Coordinator, Research Division, The B. F. Goodrich Co., Akron, Ohio, will give his talk on Testing Materials with the Atomic Bomb, supplementing this with a very interesting Navy Department film covering the bomb tests at Bikini. Mr. Stevens will supplement the film with comments and answer questions on the tests. There was intensive interest in his talk as presented at a similar meeting in Cleveland in November. The film is a remarkable record of the preparation for the tests, the actual explosions, and results.

Mr. Carpenter's talk likewise is of broad interest and covers a subject of significance to every American.

The two Districts have solicited the cooperation of various other local sections in bringing notices of the meeting to the attention of their members, and in January the Chicago meeting is a joint one with the Western Society of Engineers.

New York:

At the meeting in New York, Room 501, Engineering Societies Building, Thursday, December 12, Dr. J. R. Dunning, Professor of Physics, Pupin Laboratories, Columbia University, will cover the Future of Atomic Energy. Dr. Dunning's close participation in all phases of this subject, his presence at the Bikini test, and the experimental work he has carried out in his laboratory, all form a basis for what will be a most interesting address. All those who have heard him speak have remarked on the interesting manner in which he handles his subject. Dr. Dunning plans to supplement his talk with demonstrations and experiments.

Philadelphia:

While the subject of materials for gas turbines has been discussed at various meetings, the Philadelphia District, cognizant of the very intensive interest in this subject in the Philadelphia area, plans what promises to be a very excellent meeting at the Franklin Institute on January 23, 1947, with F. W. Godsey, Jr., Manager, New Products Div., Westinghouse Electric Corp., Pittsburgh, and Russell Franks of Electro Metallurgical Co., Niagara Falls, N. Y., scheduled to cover Use, Applications and Future of Gas Turbines. Mr. Godsey will cover their use and application in the past, and the efforts to make them work. The present widespread activity in this field will be covered, and a feature of the talk will be an estimate of the importance of this form of prime mover in future applications.

Mr. Russell Franks who was chairman of the Super Alloy Committee of the War Production Board, and who has been intensively interested in and actively connected with the materials used for high-temperature turbine application, will cover the materials that have been used to make rotors, and what may be expected for the future.

All members interested are invited to attend these meetings, and are urged to note the dates on their calendar.

Southern California Meeting on Steel Selection Chart and Application of Electric Strain Gages

THE DISTRICT meeting sponsored by the Southern California District in Los Angeles on October 29 was an unusually interesting one with the presentation of two technical papers, one "A Steel Selection Chart for the Materials Engineer," by R. A. Schaus, Columbia Steel Co., and the other "Application of Electric Strain Gages to Static and Dynamic Testing," by Given A. Brewer, Consulting Engineer. In addition, Robert C. Brumfield received the A.S.T.M. Richard L. Templin Award for his outstanding paper presented last year on "A Sulfur Print Method for the Study of Crack Growth in the Corrosion Fatigue of Metals."

The meeting was held in the Rodger Young Auditorium with 83 in attendance, including members of The American Society for Mechanical Engineers. It was noted that several large companies had individual tables of company personnel who evidenced considerable interest in both papers. Discussion of each paper followed presentation, and at the close of the meeting a further discussion took place. All present were very appreciative of the effort put forth by Messrs. Schaus and Brewer in preparing their respective papers.

The award of the Templin medal to Dr. Brumfield was made by Mr. Spalding, and in acknowledgment Dr. Brumfield credited his mother, who attended the meeting, with keeping him working on his most constructive paper.

H. W. JEWELL

Arrangements for the meeting were made by District Chairman R. B. Stringfield, and Secretary H. W. Jewell.

Cleveland Meeting on Testing with the Atomic Bomb and Progress in Rubber

PRESIDENT Arthur W. Carpenter, Manager of Testing Labs., The B. F. Goodrich Company, and H. M. Stevens, Coordinator, Research Division of Goodrich, were the chief speakers at an interesting meeting sponsored by the Cleveland District in the Cleveland Engineering Society Auditorium on Thursday, November 7. District Chairman Arthur J. Tuscany presided at the meeting and the informal dinner preceding the session, introducing a number of those present including Vice-Chairman E. G. Kimmich, of the Goodyear Tire & Rubber Co., District Secretary Ray T. Bayless, American Society for Metals, and A.S.T.M. Assistant Secretary R. J. Painter, who spoke briefly. Dr. H. E. Fritz, Vice-President in Charge of Research, the B. F. Goodrich Co., was present and was introduced to the audience. There were about 100 in attendance, inclement weather unquestionably holding down the number present.

Mr. Carpenter's address, which is to be printed in full in the January BULLETIN, did not discuss so much the technical aspects and problems in the industry as it did some of the economic and industrial problems. He stressed the very serious situation of the low crude rubber stocks prior to Pearl Harbor; the steps that were taken to meet the situation; and the rapid development of the synthetic manufacturing program. He stressed the necessity of keeping available sufficient stand-by plants to insure production capacity of, say, 200,000 tons of American rubber annually. He referred to some of the interesting work being carried on along technical lines including that on automotive rubber by the A. S. T. M. - S. A. E. joint committee. He mentioned the intensive efforts being made by the rubber industry to fill the huge demand for tires, particularly passenger car tires.

Mr. Stevens, who was the only representative of the rubber industry present at the Bikini atomic bomb tests, had much of interest to say about his experiences. He answered a number of questions on the results of both the under-water and the over-water explosions. The audience received a real thrill in his showing of the official Navy film covering the test. This brought out very drammatically the force of the explosion, and the extensive efforts made by the combined Army-Navy forces to get as much information and data as possible.

It is expected Mr. Stevens and Mr. Carpenter will repeat approximately the same program at the meeting in Pittsburgh on December 2, and in Chicago on January 7. Every member who possibly can is urged to attend; the program is a relatively short one, intensely interesting, and the film is worth making every effort to see.

Detroit District Meeting on Materials Supply

THE yearly meeting sponsored by the Detroit District was held November 13 at the Rackham Foundation Building. About two hundred were present. Immediately after dinner, members and guests had an opportunity of hearing Executive Secretary Warwick's brief description of the problems facing the Board of Directors, particularly the decisions on changes to be made in publications. The meeting proper then assembled in the auditorium to hear President Carpenter and the main speaker of the evening, Mr. Arthur Maupin, Chief of the Tin Section of the Civilian Production Administration. President Carpenter, who is also manager of The B. F. Goodrich Company's Testing Laboratory, drew on his personal experience to illustrate how mutual problems over the last eight years had drawn the producers and consumers of automotive rubber goods together to form a joint A.S. T.M.-S.A.E. Committee on the subject. The success of this committee in writing our present joint standards on these materials is a strong testimonial to the effectiveness of democratic processes.

Chairman Darsey then introduced Mr. Maupin who spoke on the very timely subject, "Materials—Where Are They?" He indicated that serious problems existed in the supplies of the following materials: iron and steel, copper, tin, lead, antimony, cadmium, zinc, and plastics. He reported that each of these current shortages has its causes somewhere in the following group of factors:

Unsatisfied civilian wartime demand.
Increased postwar rate of demand.
Strikes.
Lack of foreign production, which has reduced imports.
International controls.
The price situation.
Labor shortages in specific fields.

Output of *steel and iron* has been successively throttled by the steel strike and the spring coal strike. Now the scrap shortage threatens to reduce output again. Sheet steel is especially scarce. Housing and farm machinery needs make up a particularly urgent backlog. To ease the situation, Government agencies and 835 Industrial Salvage Committees are working to clean up obvious scrap and to expedite scrapping of obsolete or useless equipment including both ships and machinery. This will help to replace the ferrous metal sent abroad during the war, which has not returned as scrap to any great extent.

In *copper*, the situation is much the same. Supply for the present fiscal year, starting July 1, will probably be about 30 per cent behind demand. Strikes hit production very hard during the first half of 1946, and demand greatly depleted our Metals Reserve. The copper shortage may be felt for some years.

Tin will also be short for some time. In this field, we will continue to face curtailed supply until Far Eastern supplies recover to something approaching a normal level. This step awaits both rehabilitation of the physical facilities and settlement of political, economic, and labor difficulties in the area.

Our *lead* reserve has been dwind-

ling steadily since 1944 and now, having reached a very low figure, about three weeks' supply, it has been frozen. Accordingly, we will have to get along on our current supplies, which equal about two-thirds of demand. Two bottlenecks impede production; first, the lack of mine development work during the war, and second, the migration of labor to other kinds of work. The former difficulty, at least, will take years to overcome. For the present, our chief emergency measure must be recovering scrap as promptly and efficiently as possible.

Since Chinese *antimony* supplies are cut off by civil war, it has been necessary to develop low-grade domestic sources. Supply currently equals 70 per cent of anticipated demand, but about 200 per cent of prewar demand.

The *cadmium* situation is tight, but may be improved, if a price rise in cadmium should divert part of the demand to other metals or if increased zinc production occurs, since cadmium is a by-product of zinc and lead production.

Wartime imports of *zinc* have fallen off since 1943, so, although domestic production has held up to prewar levels, postwar demands now outstrip supply by about 10 per cent.

Rubber presents a brighter picture. Total supply of natural plus synthetic rubber is adequate, although there is still a shortage of natural rubber.

Plastics will undoubtedly be used in greatly increased amounts in the future, but raw material shortages, as well as shortage of building materials for plant construction, appear almost certain to be limiting factors. The reduced cotton crop and lumber output have cut the supply of cotton linters and wood flour. The former will affect the production of high tenacity rayon for automobile tires.

During the question period, discussion centered around three main points:

First, with regard to return of military scrap from overseas, very little has been done along this line. We will possibly receive it from foreign scrap collectors in the future.

Second, the general price increase now under way may increase supply in many fields.

Third, Mr. Carpenter contributed a brief summary of the anticipated rubber supply situation, indicating that we face a potential oversupply of rubber, and that when this condition becomes actual, maintenance of our strategic synthetic rubber industry will require at least partial protection against natural rubber imports, which came in at less than three cents a pound during the early nineteen thirties.

E. T. Johnson, Chrysler Corp.

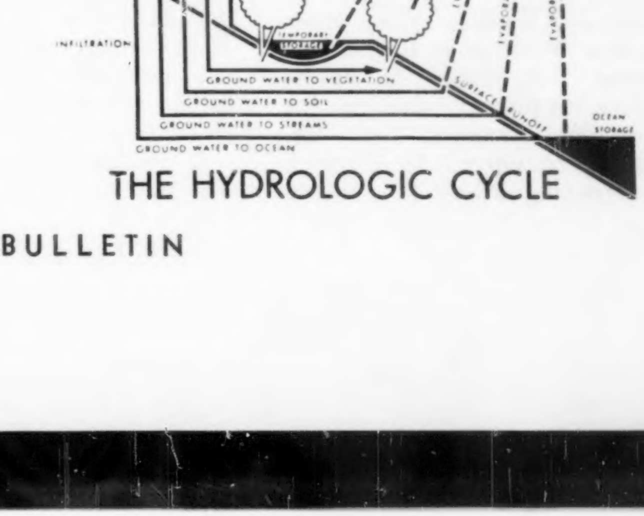
Philadelphia District Meeting on Industrial Waters

The first of four meetings of the Philadelphia District of A.S.T.M. was held at the Franklin Institute on Thursday evening, November 14th. The meeting was preceded by a dinner at the Robert Morris Hotel.

District Chairman J. F. Vodges, Jr., opening the session on Water for Industry, announced that the next meeting of the Philadelphia District on January 23 will feature a technical session with Gas Turbines as the subject. In February, in connection with A.S.T.M. Committee Week and the 1947 Spring Meeting and the formal Dedication of the Society's new headquarters at 1916 Race Street, the Philadelphia District will sponsor with Committee D-1 a Symposium on Paint, and in March a technical session on Textile Processing. He then introduced L. Drew Betz, President of W. H. and L. D. Betz, Chemical Engineers, the first speaker of the evening.

Mr. Betz explained how water, one of the basic raw materials of industry, is not just simply H_2O as high-school students first learn. As it passes through the hydrologic cycle it picks up gases from the air and dissolves calcium and magnesium and additions—present in varying amounts in all waters according to their history—are present in minute but significant quantities—in parts per million. These impurities determine whether water is suitable for human consumption and for various industrial uses. Waters suitable for some uses, he explained further, may not be suitable for others. It is of interest to note, he added, that water treatment has an ancient history—the first record being the treatment of the waters of Marah by Moses (*Ex.* 15:22). For a discussion of modern water treatment he turned the meeting over to J. J. Maguire, Director, Technical Division of his company.

Mr. Maguire told how the impurities that are in raw water are removed or controlled to make it suitable for various uses. He explained the characteristics of each type of treatment, what it could do and what it could not do. Aeration, coagulation, filtration, lime-soda and zeolite softening, chlorination, etc., were each treated in turn and the audience given a very clear and vivid explanation of each. Both speakers used slides to illustrate their stories, and the audience left



THE HYDROLOGIC CYCLE

with a much clearer understanding of what water is, how it gets that way, and what can be done to modify it and make it what it is— industry's most used material.

He noted one pertinent, and probably little known statistic—that 75 per cent of the world's available surface water supply is concentrated in this country and its borders.

300 at First New England Technical Meeting—Stress Analysis Discussed

The first technical meeting to be sponsored by the New England District, organized early this year, was a most interesting and successful one with about 300 present. Held on Nov. 21 an excellent program on Experimental Stress Analysis and Methods of Visual Measurement of Stress was presented by Messrs. Murray, Ruge, and Ellis, who have for many years carried out intensive work in their various fields. District Chairman H. L. Sherman, of Skinner & Sherman, Inc., presided at the meeting, introducing the district members present including Vice-Chairman C. J. Altieri and Secretary Miles N. Clair. A.S.T.M. Assistant Secretary R. J. Painter spoke briefly about the Society, pointing out the concentration of A.S.T.M. work since its inception almost fifty years ago in developing data and knowledge on the properties and testing of materials, and developing standard specifications and tests which are not only widely used on this continent but throughout the world.

Professor Walter C. Voss, Head, Department of Building Engineering and Construction, Massachusetts Institute of Technology, who had arranged the interesting program as Chairman of the Program Committee introduced Dr. William M. Murray, Associate Professor of Mechanical Engineering at M.I.T., who in turn presented Dr. Arthur C. Ruge, Partner of Ruge-deForest Associates, and Mr. Greer Ellis, Consulting Engineer, Magnaflux Corporation, New York City. Due to the careful planning and clear and concise presentation by Professor Murray the program was not a long, tedious one as might be expected with three speakers and other formalities, but actually permitted the showing of an interesting film describing the application of stress analysis to a large aircraft wing at Glenn L. Martin Co. Beginning shortly after 8 p.m. the program was completed about 10:15 o'clock and there were a number of very pertinent questions from the audience which the speakers covered.

Dr. Murray gave an excellent review of the field of experimental stress analysis using numerous, well-selected slides to demonstrate the three particular phases involved, namely photo-elastic analysis, the use of stress coatings, and finally the background and applications of wire strain gages. Having done pioneering work in this field of visual measurement of stress, Dr. Murray was able to convey to his audience a good background for the discussions and answers to queries which were given by Messrs. Ruge and Ellis. Dr. Ruge had several exhibits showing the application of the wire gages and the methods of measurement.

Offhand one might expect that a meeting of this type would be of interest very largely only to those concerned with the field of metals and structures but it was quickly apparent during the question period that the various men present from a variety of industries—textile, gaseous fuels, and others—not only enjoyed the meeting but had some real practical questions involving the application of the theory and instruments and equipment used, to their own particular problems. One could not help feeling that although much progress has been made in solving important problems by experimental stress analysis, there are a great many more perplexing problems where use of the methods may give us the answer to some situations which are now either solved through very laborious and costly effort or merely handled by cut-and-try methods.

Professor Voss had arranged to use Huntington Hall at the Massachusetts Institute of Technology, which was fortunate because of the good turn-out, and he also arranged for publicizing the meeting and took care of other details so that to him should go much credit for what one member present said was one of the finest technical meetings he had attended.

St. Louis District Hears L. J. Markwardt

About 65 members and guests of the St. Louis sections of the A.S.T.M. and A.S.M.E. attended a joint dinner meeting November 15 in the Stockholm Room of the Park Plaza Hotel. The featured speaker of the evening was Mr. L. J. Markwardt, Assistant Director, U. S. Forest Products Laboratory, Madison, Wis., whose topic was "Wood as an Engineering Material." Preceding Mr. Markwardt on the program was President Arthur W. Carpenter and Executive Secretary C. L. Warwick each speaking briefly in greeting the assemblage and stressing the interlocking of interests between the two societies represented.

Mr. Markwardt's talk had been widely heralded among the various interested professions in St. Louis, and he began his talk under the handicap of high hopes and expectations which had been raised in the minds of the audience by virtue of the heavy "build-up" that had been given the occasion of his address. It redounds especially to his credit, therefore, that in no way was any listener disappointed—and this applies equally to the few wives of members who were present.

Beginning by reciting the marvels of a "newly discovered" substance, *doow*, as it might have been proclaimed by the publicity department of its originators, Mr. Markwardt proceeded to remind us of all that wood (*doow*) (*backwards*) means in our everyday life. From that point, the next step was to stress the necessity for its intelligent use (conservation) followed by an interesting "exposé" of the life of a tree, with the explosion of several myths and misconceptions about it, then into a consideration of the micro-

aspects and cellularstructure of wood and finally an extended discussion of the new uses and treatments which have been devised to further its usefulness to mankind. Various types of plywood and treatments were discussed, due credit being given to the improved glues now in use. A long table of exhibits, illustrating the speaker's points, was on view and extensive use of lantern slides further enhanced an understanding of the speakers subject.

J. C. Parmely, Chairman of the St. Louis Section of the A.S.M.E., opened the evening session and then turned it over to A.S.T.M. Chairman G. L. Oliensis, who ably "m.c.'d" the remainder of the program.

Messrs. Markwardt, Carpenter, and Warwick were also guests at an informal luncheon held at the Jefferson Hotel the same day as the evening meeting. This was given over to strictly A.S.T.M. talk on a general discussion basis. Nineteen attended and all were interested in what Mr. Carpenter and Mr. Warwick had to say about A.S.T.M. plans and accomplishments. Our venerable Past Chairman, Dr. Von Schrenk, was unable to attend either meeting because of ill health but Mr. Markwardt visited him in the morning and was able to report he was making satisfactory progress.

S. B. Roberts

Planning and arrangements for this meeting, the first held in St. Louis in several years, were spearheaded by the District officers, Messrs. Oliensis, Brust, and Roberts who should receive full credit for a renewal of A.S.T.M. activity there.

Publication on Graphitization of Steel Piping

The several papers presented at the 1945 Annual Meeting of The American Society of Mechanical Engineers in a session sponsored by the Joint A.S.T.M.-A.S.M.E. Research Committee on the Effect of Temperature on the Properties of Metals, have been issued in the form of a special reprint and copies can be obtained from the office of either Society, the A.S.M.E. being located at 29 West 39th Street, New York 18, N. Y.

The reprint comprises six papers with discussion totaling 60 pages, page size 8¼ by 11 in. Papers and discussion in the reprint cover the following subjects: Report on the Joint E.E.I.-A.E.I.C. Investigation; Susceptibility of Casting Steels to Graphitization; Comparative Graphitization of Some Low-Carbon Steels; Graphitization in Aluminum-Killed Carbon-Molybdenum Piping; Graphitization in Cast Steels; Heat-Treatment and Graphitization; General Discussion. There is no charge for the reprint but the supply is limited.

Society Represented at University of Utah Inauguration

Through the cooperation of E. H. Beckstrand, Professor Emeritus of Mechanical Engineering, University of Utah, and a long-time member of the Society, A.S.T.M. was represented at the Inauguration Ceremony of Albert Ray Olpin as President of the University of Utah on October 16. Professor Beckstrand has been a member of A.S.T.M. since 1907, and until his retirement in 1941 was on the faculty at the university for 39 years.

To the A.S.T.M. Committee on Membership, 1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below.

____

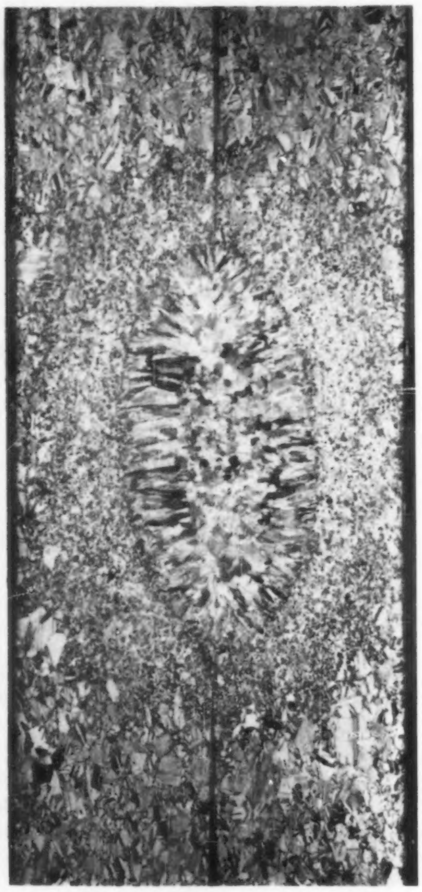
____

This company (or individual) is interested in the following subjects: (indicate field of activity, that is, petroleum, steel, non-ferrous, etc., etc.)

____

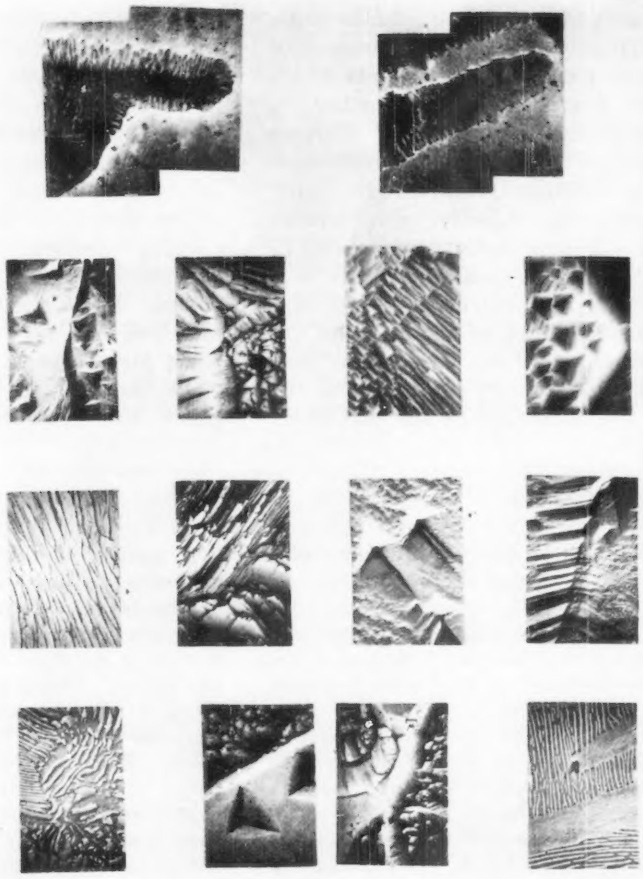
(Signed)____________________

Date________________ Address____________________



"Spot-Welded Yellow Brass Sheet. Original-X10, Enlarged-X3"
(Reduced one third in Printing)

Third prize-winning photograph, Photomicrographic Section, in the Fifth A.S.T.M. Photographic Exhibit, by Harold W. Hughson, Chase Brass and Copper Co.



"Series of 14 Related Collodion Replicas Prepared by Shadow Casting Technique X5000."
(Reduced one half in Printing)

Second prize-winning photograph, Electron Microscope Group, in the Fifth A.S.T.M. Photographic Exhibit, by Helmut Thielsch, Allis-Chalmers Mfg. Co.

To the A.S.T.M. Committee on Membership

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on membership in A.S.T.M. and include a membership application blank.

(Signed)————————————

Address————————————

————————————

Date————————

ASTM Bulletins—1946

Subject Index—Papers, Reports, and Articles

Index to Authors of Technical Papers

1946 ASTM Bulletins

While this Author Index does not list authors according to alphabetic sequence and the titles of some of the papers are condensed, it is believed the information as presented will be of service. Further details are given in the Subject Index.

Refractories Committee Meets at Battelle Institute

Battelle Memorial Institute, Columbus, Ohio, was host to Committee C-8 on Refractories at its fall meeting held November 14 and 15. Twenty-six members and four visitors were in attendance at the main committee session.

The aggressive attitude of this committee, which is one of the older technical committees of the Society, in maintaining the various standards under its jurisdiction in up-to-date shape, was very much in evidence at the meeting. Approval was given on the elevation of seven tentative methods and one specification to standard, the tentative revision of seven standard methods, the elevation to standard of thirteen tentative revisions of standards, and the revision of two tentative revisions of standards.

Briefing through the lengthy agenda of the several subcommittee meetings, one of the important items discussed was the need for proposed time-temperature schedules for basic and silica brick, to be included in the Standard Method of Testing Fireclay Refractories Under Load at High Temperatures (C 16–41). An investigation of oxy-acetylene and electrically heated P.C.E. furnaces will be undertaken for comparative data. A recommended practice to be used with procedures on heat transfer was approved for inclusion in the 1947 revision of the Refractories Manual. Several revisions of Definitions of Terms Relating to Refractory Materials (C 71–45) were accepted as well as new definitions covering dead-burned magnesite, chrome ore, chrome brick and magnesite brick.

Discussion on the A.S.T.M. classification nomenclature covering fire clay refractories disclosed that this nomenclature has not been universally adopted by the industry over the older nomenclature based on first, second, and third quality classifications. The consensus was expressed that the A.S.T.M. classification was superior in all respects

and should receive greater promotion by the committee members.

A comprehensive report was presented by the Subcommittee on Petrographic Techniques Applied to Refractories. This will be included in the new Refractories Manual, scheduled for release in April, 1947.

The activities in the field of industrial furnace surveys include a revision of the present one on open-hearth furnaces and the lead industry as well as a new survey on steel pouring pit practice.

The next meeting of Committee C-8 will be held in Washington, D. C., in March, 1947.

Industrial Research Laboratories of the United States

THE eighth edition of the publication entitled "Industrial Research Laboratories of the United States" gives information on 2443 industrial laboratories. Data include the companies, addresses, names of the research directors and top associates, number of people on the staff, and a condensed statement on research activities and number of volumes in the laboratories library. Callie Hull, Librarian of the National Research Council, in the preface to the book points out that the first edition of this bulletin, issued in 1920, contained a listing of 297 companies. Increasing emphasis on research activities is also strikingly shown by a chart which indicates that as of 1946 there were at least 133,000 individuals engaged in laboratory work, which figure compares with about 70,000 in 1940.

In compiling the information those responsible have interpreted research in accordance with the following definition:

"Industrial research is the endeavor to learn how to apply scientific facts to the service of mankind. Many laboratories are engaged in both industrial research and industrial development. These two classes of investigation commonly merge so that no sharp boundary can be traced between them. Indeed, the term 'research' is frequently applied to work which is nothing else than development of industrial processes, methods, equipment, production or by-products."

The 426-page Directory also includes in the appendix for the first time a list of educational institutions which offer research service to industry, and there are three indexes providing; a Geographical Distribution of Laboratories; a Personnel Index (containing more than 7000 names); and a Subject Index of Research Activities.

This National Research Council Bulletin No. 113 will undoubtedly be of much interest and value to many members of A.S.T.M. Copies can be procured from the National Research Council, National Academy of Sciences, Washington, D. C., at $5.00 each.

Engineering Section AAAS to Meet

SOME fifteen technical papers are scheduled for presentation at the meeting of the Engineering Section of the American Association for the Advancement of Science in Boston, December 26 to 31, inclusive. The preliminary announcement from Prof. F. D. Carvin, Newark College of Engineering, who is Secretary of Section "M," notes the following program:

Saturday, December 28, 1946
9:30 A.M.

Papers by the U. S. Navy, Office of Research and Invention

1. Basic Research on Jet and Rocket Propulsion—Commander L. M. Slack
2. RamJet Research and Development—Dr. Hafstedd
3. Future of Aircraft Power Plants—Ivan Driggs

1:30 P.M.

4. Gas Turbines—J. T. Rettaliatta
5. Electronics—E. R. Piore and R. M. Page
6. High Altitude Research (V-2 Rockets)—E. H. Krause

Monday, December 30, 1946

Papers by the U. S. Army Air Forces, Wright Field

9:30 A.M.

7. Determination of the Temperature Distribution in a Gas Turbine Wheel—I. Perlmutter
8. Exhaust Cooling, Aircraft Engine Testing Facilities—P. M. Sartell
9. Armament Trends—J. E. Clemens
10. Aircraft Cabin Supercharging and Air Conditioning by Engine Bleed-off —R. B. Keusch
11. The Fundamental Research Necessary for the Evaluation of Cooling Requirements of Supersonic Aircrafts and Missiles—D. M. Patterson

1:30 P.M.

12. Problems of Army Air Force Photography—A. M. Katz
13. Jet Propulsion Thrust Augmentation with Water Injection and Afterburning
14. Fuel Tank Protection by Means of Restricted Leakage and Controlled Drainage—H. Noyes
15. Papers on the Army Research on Electronics

The Engineering Section meetings will be in Room 250, Building 10, Mass. Institute of Technology, and the Hotel Headquarters will be the Kenmore Hotel, Kenmore Square, Boston, Mass. Hotel reservations should be sent to AAAS Housing Bureau, Convention Bureau, Chamber of Commerce, 80 Federal Street, Boston 10, Mass.

A.S.T.M. Publishes Report on Textile Testing in Germany

AT THE October meeting of A.S.T.M. Committee D-13 on Textile Materials there was presented a most interesting paper, essentially a condensed report, giving the highlights of an intensive investigation of textile testing in Germany, this work having been part of our Government's program of having leading technologists and scientists determine the state of progress of the various industries and scientific work in Germany. While it is expected that this condensed report will be published in the January BULLETIN, in the meanwhile reprints of the article which will cover about 12 pages have been struck off, and those interested can procure separate copies at 50 cents each. The report is profusely illustrated with some excellent photographs of unique German instruments, and the authors, Herbert F. Schiefer and Lyman Fourt, Senior Physicist and Research Associate, respectively, of the National Bureau of Standards, and Richard Kropf, Director of Research, Belding Heminway Corticelli Co., have included pertinent descriptive material. In addition to details of various instruments there is discussion on some other matters relating to the textile field, for example, the status of German standards work.

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
December 12	NEW YORK DISTRICT	New York, N. Y.
January 7, 1947	CHICAGO DISTRICT	Chicago, Ill.
January 16, 17, 18	D-2 on Petroleum	Washington, D. C.
January 20, 21	Board of Directors	Philadelphia, Pa.
January 23	PHILADELPHIA DISTRICT	Philadelphia, Pa.
February 24–28	SPRING MEETING AND COMMITTEE WEEK	Philadelphia, Pa.
March 12, 13, 14	D-13 on Textiles	New York, N. Y.
June 16–20	50TH ANNUAL MEETING	Atlantic City, N. J.

New Members to November 21, 1946

The following 52 members were elected from October 1 to November 21, 1946, making the total membership 6136.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

HESSE, ALFRED H., Research Metallurgist, R. Lavin and Sons, Inc., 3426 S. Kedzie Ave., Chicago 23, Ill.

HOOVER, HELEN D., Chemist, Metallurgist, Ahlberg Bearing Co., 3025 W. Forty-seventh St., Chicago 32, Ill. For mail: 1210 Jarvis Ave., Chicago 26, Ill.

JAMESON, ALFRED S., Assistant Supervisor of Metallurgy, Research, International Harvester Co., 5225 S. Western Blvd., Chicago 9, Ill.

WILDER, SAMUEL B., Chief Chemist, Mastic Asphalt Corp., 1507 S. Olive St., South Bend 24, Ind. [J]*

Cleveland District

RADIART CORP., THE, W. C. Mock, Jr., Chief Engineer, 3571 W. Sixty-second St., Cleveland 2, Ohio.

GELLIN, HARRY, President, The Gellin Co., 2021 Euclid Ave., Cleveland 15, Ohio.

Detroit District

WELLS, WILLIAM T., Junior Engineer, Chrysler Graduate School, 12260 Oakland Ave., Highland Park, Mich. For mail: 44 Richton Ave., Highland Park 3, Mich. [J]

New England District

CORNISH WIRE CO., INC., Manley T. Mallard, Assistant Manager, 101 Water St., Williamstown, Mass.

GOODALL-SANFORD, INC. Frank Fleming, Chemist, Sanford, Me.

HERBERT, MAURICE S., President, Franklin Paint Co., Franklin, Mass.

New York District

EKSTRAND & THOLAND, INC., Jerome F. Kuzmick, Manager, Metal Powder Dept., 510 Broad St., Carlstadt, N. J.

EVERSHARP, INC., H. Willis, Vice-President, 32–36 Forty-seventh Ave., Long Island City 1, N. Y.

KOUSH, DOROTHY THERESA, Director, Bureau of Standards, Lord & Taylor Department Store, 424 Fifth Ave., New York 18, N. Y. [J]

MACIA, WILLIAM F., Technical Director, Stern & Stern Textiles, Inc., 1359 Broadway, New York 18, N. Y.

MASSETTI, PIO A., Managing Director-Chemist, Public Service Testing Laboratories, 381 Fourth Ave., New York 16, N. Y.

ROUND, GEORGE A., Chief Automotive Engineer, Socony-Vacuum Oil Co., Inc., 26 Broadway, New York 4, N. Y.

TURECEK, JOSEPH, Director of Physical Testing, Sidney Blumenthal and Co., Inc., Shelton, Conn.

Northern California District

SAN FRANCISCO, CITY AND COUNTY OF, Department of Public Works, Bureau of Engineering, Room 351, City Hall, San Francisco 2, Calif.

Philadelphia District

SNEDAKER AND CO., INC., FRANK C., Paul A. Muehlman, Vice-President, 3537 N. Ninth St., Philadelphia 40, Pa.

GLASSGOLD, I. LEON, Instructor, 6276 N. Fifteenth St., Philadelphia 41, Pa. [J]

GREEN, RALPH E., Sales Engineer, Thwing-Albert Instrument Co., Penn St. and Pulaskie Ave., Philadelphia 44, Pa. For mail: 420 Tregaron Rd., Bala-Cynwyd, Pa.

MAGUIRE, JOHN J., Director, Technical Division, W. H. & L. D. Betz, Gillingham and Worth Sts., Philadelphia 24, Pa.

VANNOY, WESLEY G., Chemist, E. I. du Pont de Nemours and Co., Newport, Del.

Pittsburgh District

ELECTRICAL REFRACTORIES CO., THE, Hector B. Moore, Superintendent, East Palestine, Ohio.

WATSON-STANDARD CO., THE, Ira R. Messer, Vice-President, 225 Galveston Ave., Pittsburgh 12, Pa.

DENNISON, BROOK J., Chemist, Pittsburgh Plate Glass Co., Creighton, Pa.

WEST, V. WAYNE, Chief, Inquiry and Specifications, Pittsburgh Steel Co., Allenport, Pa.

Western New York and Ontario District

GOCKER, J. PAUL, Package Engineer, Eastman Kodak Co., Kodak Park, Rochester 4, N. Y. For mail: 152 Plymouth Ave., South, Rochester 8, N. Y.

HOCH, V. P., Foreman, Physical Testing Lab., Eastman Kodak Co., Camera Works, Rochester 4, N. Y.

WIEGAND, EUGENE J., Supervisor, Department of Manufacturing Experiments, Kodak Park Works, Rochester 4, N. Y.

U. S. and Possessions

BRISTOL LABORATORIES, INC., N. F. Murphy, Director, Engineering and Development Div., Box 657, Syracuse 1, N. Y.

INTERNATIONAL PRODUCTS CORP., Edward Porst, Engineer, 2554 Greenmount Ave., Baltimore 18, Md.

SIMPSON INDUSTRIES, INC., Paul D. Close, 1010 White Bldg., Seattle 1, Wash.

SOUTHERN NAVAL STORES DIVISION OF LEACH BROTHERS, INC., C. S. Batson, Chemist, Columbia, Miss.

VIRGINIA RUBATEX, DIVISION OF GREAT AMERICAN INDUSTRIES, INC., Samuel P. June, Chief Chemist, Bedford, Va.

BELLOWS, K. C., Contractor-Engineer, 10 S. Linden Ave., Sheridan, Wyo.

COZENS, ARTHUR E., Chief of Engineering Laboratory Section, Army-Navy Medical Procurement Office, Engineering Development Division, Carlisle Barracks, Pa. [J]

FROGUE, CHARLES I., Chief Chemist, Charles Martin and Co., 1215 Dumble St., Houston 3, Tex. For mail: 4305 Bell Ave., Houston 3, Tex.

NASON, H. K., Director of Development, Monsanto Chemical Co., Central Research Dept., Dayton 7, Ohio.

NEAL, JOSEPH L., JR., Assistant Professor, Department of Chemistry, Syracuse University, Syracuse 10, N. Y.

PAASCHE, OLAF G., Assistant Professor of Mechanical Engineering, Oregon State College, 206 Engineering Laboratory, Corvallis, Ore.

SIMONS, SANFORD L., Research Engineer, Alldredge & Simons Laboratories, 2049 Champa St., Denver 2, Colo. [J]

Other than U. S. Possessions

COMPAÑIA GENERAL DE ASFALTOS Y PORTLAND ASLAND, Barcelona, Spain.

KLEBER-COLOMBES, Etienne de Meeus, Secretaire Général Technique, 26 Avenue de l'Opera, Paris I, France.

PHILIPS ELECTRICAL INDUSTRIES OF AUSTRALIA PTY., LTD., 69 Clarence St., Sydney, Australia.

BRITISH MINISTRY OF SUPPLY, Chemical Inspection Dept., "The Cloisters," Southborough Rd., Bromley, Kent, England.

FARINATI, EDUARDO, Sección Bibliotecas de Marina, Casilla de correos No. 3193, Buenos Aires, Argentina.

GÓMEZ, HORACIO J., Sección Bibliotecas de Marina, Casilla de correos, No. 3193, Buenos Aires, Argentina.

KRASSA, PABLO, Dean, School of Physical Science and Mathematics, Universidad de Chile, Casilla 2126, Santiago, Chile.

SERDAROGLU, NAMI, Professor of Chemistry, Teknik Üniversite, Beyoglu, Istanbul, Turkey.

VILA, ELISEO, Metallurgical Engineer, Sección Bibliotecas de Marina, Casilla de correos No. 3193, Buenos Aires, Argentina.

VOORHOEVE, N. A. J., N. V. Philips' Gloeilampenfabrieken, Eindhoven, The Netherlands.

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* [J] Denotes Junior Member.

Personals . . .

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

PAUL C. CUNNICK, Lieutenant Colonel, Officer in Charge of Laboratory, Rock Island Arsenal, Rock Island, Ill., has been called to active duty in Europe.

CLARENCE H. SAMPLE, formerly Chief Engineer, Rheem Research Products, Inc., Baltimore, Md., is now connected with The International Nickel Co., New York, N. Y., where he is associated with R. J. McKay, Chemical Engineer.

V. H. BRADFORD, who was Vice-President and General Manager, Bennett Steel Treating Co., Newark, N. J., is now Plant Manager, American Greeting Publishers, Inc., Cleveland 5, Ohio.

W. B. F. MACKAY is now Instructor in Metallography, University of Minnesota, Minneapolis, Minn. He was Wing Commander, Royal Canadian Air Force, Winnipeg, Manitoba, Canada.

C. B. THOMPSON, formerly Ordnance Engineer, Army Service Forces, Washington, D. C., is now Graduate Student, University of Iowa, Iowa City, Iowa.

VICTOR NEWTON is now out of the service and is a graduate student at the College of the City of New York, N. Y.

CHARLES ROBERTS has been associated with the late W. D. McCormick, Architect, located in Pittsburgh, but has now opened his own Architectural Office at 539 N. Homewood Ave., Pittsburgh 6, Pa.

C. A. NASH, formerly Consulting Chemist, Bakelite Corp., Bloomfield, N. J., is now Plastic Consultant located in North Caldwell, N. J.

E. J. SWAILES, formerly Staff Assistant to Production Manager, Glenn L. Martin Co., Baltimore, Md., is now Operations Manager, Goodwill Industries, Chicago, Ill.

MERRITT A. WILLIAMSON, formerly Lieutenant (J.G.) Naval Ordnance Test Station, Inyokern, Calif., is now Director of Technical Research, Solar Aircraft Co., San Diego, Calif.

P. S. TROWBRIDGE, who was Vice-President of the Hydraulic-Press Brick Co., St. Louis, Mo., has retired from active service with the company.

M. REA PAUL, formerly Chief, Operations Bureau, Smaller War Plants Corp., Washington, D. C., is now associated with Frederic H. Rahr, Inc., New York, N. Y.

E. S. HODGE, formerly Consulting Spectrographer, Applied Research Labs., Detroit, Mich., is now Senior Chemist, Eastman Kodak Co., Rochester, N. Y.

L. A. WEINLAND is now Associate Professor of Chemistry, Champlain College, Plattsburg, N. Y. He was Research Associate, Ohio State University Research Foundation, Columbus, Ohio.

E. R. O'HARE, who was Technical Director, Casein Co. of America, Division of The Borden Co., New York, N. Y., is now Vice-President and Technical Director, Caribbean Plywood and Plastic Corp., San Juan, Puerto Rico, with offices in San Juan and New York. Mr. O'Hare is located in the New York office.

VISCOUNT DE ALMEIDA GARRETT, formerly Civil Engineer, and Director Engineer, Laboratory to Study and Test Cork, Department of Economy, Lisbon, Portugal, is now Civil Engineer, General Direction of Buildings and Monuments, Department of Public Works, Portugese Government; and is Partner and Technical General Director, Cork Manufacturing Society "Socorguex Ltd.," Lisbon, Portugal.

W. V. PRINCE is now Consulting Engineer with offices in Kansas City, Mo. He was formerly President and Chief Engineer, Prince Industrial Plastics Corp., Cleveland, Ohio.

J. R. CARLSON is now with the Public Service Electric and Gas Co., Maplewood, N. J. He was formerly with Electrical Testing Laboratories, Inc., in New York City.

HENRY MUSCH, 3d, formerly Captain, Production Engineering Officer, Ordnance Department, U. S. Army, is now Production Engineer, A. E. Broughton and Co., Sanford's Ridge, Glens Falls, N. Y.

E. E. HUSSEY is now connected with the Globe Hoist Co., in Philadelphia, as Sales Engineer. He was Standards Engineer, Raytheon Manufacturing Co., Waltham, Mass.

M. DAVIS ALEXANDER who was a Specification Writer, in Houston, Texas, is now associated with Wyatt C. Hedrick, Architect and Engineer, in Houston.

WILLIAM FURBER SMITH who was connected with Carbide and Carbon Chemicals Corp., SAM Laboratories, New York, is now Chief Engineer, Hartford-Empire Co., Hartford 1, Conn.

R. S. STAINTON, who was with the Bradley Polytechnic Institute, Peoria, Ill., is now with Case School of Applied Science, Cleveland, Ohio.

M. T. HOFFMAN, formerly Technical Director, Merrimac Hat Corp., Amesbury, Mass., is now a Textile Consulting Engineer located in Newburyport, Mass.

P. H. DESROSIERS is now Executive Vice-President, Joliette Steel, Ltd., Montreal, P. Q., Canada. He was Managing Director, Sorel Steel Foundries, Ltd., Montreal, P. Q., Canada.

H. L. WHITTEMORE who recently retired as Chief, Engineering Mechanics Section, VI-5, National Bureau of Standards, Washington, D. C., is now located in Washington as a Mechanical Engineer.

R. L. STREETER has returned to the United States after doing construction work for the War Department. He is now resuming his practice as an Engineer Consultant in Casper, Wyoming.

THEODORE R. DONLAN, formerly Chemist in Charge, Solvents Development Laboratory, Standard Alcohol Co., Elizabeth, N. J., is now Solvent Specialist, Standard Oil Co. of New Jersey, New York, N. Y.

P. D. MIESENHELDER is now Engineer of Materials and Tests, Indiana State Highway Commission, Department of Materials and Tests, Indianapolis, Ind.

CHARLES D. TOWNSEND, formerly Plant Superintendent, S. K. Wellman Co., Cleveland, Ohio, is now Chief Industrial Engineer, A. B. Chance Co., Centralia, Mo.

J. K. RUMMEL, formerly Chief Chemist, Shanghai Power Co., Shanghai, China, is now Chemical Engineer, Sheppard T. Powell, Baltimore, Md.

L. E. WELCH, is now Metallurgist, McConway & Torley, Pittsburgh, Pa. He was Metallurgist, The Ohio Steel Foundry Co., Springfield, Ohio.

HOWARD K. NASON has been promoted to Director of Development, Central Research Department, Monsanto Chemical Co., Dayton, Ohio.

ROBERT M. PARKE has been appointed Division Engineer in Charge of Metallurgical Research of the Kellex Corp. Formerly Director of Metallurgical Research of the Climax Molybdenum Co., Mr. Parke will be assigned to the Research Unit of the Johns Hopkins University, Applied Physics Laboratory, 8621 Georgia Ave., Silver Spring, Md., with which the Kellex Corp. has recently become associated in a series of special projects for the U. S. Navy.

At the First Annual Conference and Exhibit of the Instrument Society of America, RICHARD RIMBACH, Editor, *Instruments Magazine*, Pittsburgh, Pa., was elected Secretary.

EDGAR C. BAIN, Vice-President, Research and Technology, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., received the Albert Sauveur Achievement Award, at the A.S.M. meeting at Atlantic City in November. Dr. Bain was honored in recognition of metallurgical achievement which has stimulated other organized work along similar lines to such an extent that a marked basic advance has been made in metallurgical knowledge, specifically his work in developing a new conception of the heat treatment of steel.

G. E. F. LUNDELL, Chief, Chemistry Division, National Bureau of Standards, Washington, D. C., was re-elected a member of the Advisory Board of the *Analytical Edition of Industrial and Engineering Chemistry* for a term of three years, beginning January 1, 1947.

Arkansas State College, Jonesboro, Ark., about 75 miles northwest of Memphis, is inaugurating a course in engineering, according to CHARLES H. BONNEY, Head of the Engineering Department. New laboratory equipment is being procured, and it is pointed out that most of the college buildings are of relatively recent construction and there are adequate facilities to handle single men in permanent dormitories.

DR. JOHN JOHNSTON has retired as Director of the Research Laboratories, U. S. Steel Corp., Kearny, N. J. This laboratory was established under his direction in 1928, and in addition to the large number of scientists engaged there, many more received their training at the laboratory and now serve in the various operating companies. A native of Scotland, he has served in the Geophysical Laboratory, Washington; the American Lead, Zinc and Smelting Co.; U. S. Bureau of Mines; and was head of the Department of Chemistry at Yale. His successor at Kearny is DR. J. B. AUSTIN, a Lehigh graduate who studied under Dr. Johnson at Yale and who has been associated with him since 1928.

COLONEL R. R. LITEHISER recently returned from Germany where he served as Assistant Chief of Transportation for the European Theatre of Operations. He entered the Army in 1941 and prior to going overseas served successively at the New York Port of Embarkation; Instructor at the Command and General Staff School, Fort Leavenworth, Kans.; Director of Troop Movement at the Hampton Roads Port of Embarkation; and Assistant Commandant, Transportation Corps Officer Candidate School at New Orleans. Colonel Litehiser has resumed his pre-war job as Chief Engineer, Ohio State Highway Testing and Research Laboratory at Columbus, Ohio, and plans to participate again in A.S.T.M. work.

F. M. CRAPO, Vice-President, Indiana Steel and Wire Co., Muncie, Ind., presented the Mordica Memorial Lecture on "Galvanizing Steel Wire" at the recent annual convention of the Wire Association held at the Hotel Statler in Buffalo, N. Y.

D. V. TERRELL, formerly Assistant Dean of Engineering, is now Dean, College of Engineering; Director, Kentucky Engineering Experiment Station, University of Kentucky, Lexington, Ky.

D. GARDNER FOULKE, who was Director, Analytical Laboratory, Foster D. Snell, Inc., Brooklyn, N. Y., is now Process Electrochemist with Hanson-Van Winkle-Munning Co., Matawan, N. J.

EDGAR M. HASTINGS, Chief Engineer, Richmond, Fredericksburg & Potomac Railroad Co., Richmond, Va., has been nominated as the 1947 President of the American Society of Civil Engineers. Mr. Hastings will take office at the society's annual meeting in New York in January.

Correction

One of those errors which seem to creep in to publications despite every act to eliminate them occurred in the August BULLETIN when the address of BRYANT MATHER, who was moving with the Corps of Engineers' Concrete Laboratory from Mount Vernon, N. Y., showed that he was going to the U. S. Waterways Experiment Station at Clinton, *Massachusetts*. This should have been Clinton, *Mississippi*.

A. C. Fieldner Receives 1946 Nicholls Award

FOR his outstanding work in the field of fuel technology, Dr. A. C. Fieldner, Chief, Fuels and Explosives Service, U. S. Bureau of Mines, Washington, D. C., and past-president of A.S.T.M., recently received the 1946 Percy Nicholls Award, a joint recognition on the part of the A.I.M.E. Coal Division and the A.S.M.E. Fuel Section. The presentation was made at the meeting in Philadelphia in October by Dr. A. W. Gauger, Director, Mineral Industries Experimental Station, The Pennsylvania State College, State College, Pa., and Chairman of A.S.T.M. Committee D-3 on Gaseous Fuels. It was pointed out that the recipient of the award had always taken a friendly interest in those associated with him (Dr. Fieldner was Dr. Gauger's first employer) and that he had devoted almost 40 years to his work at the U. S. Bureau of Mines. A Past-President of A.S.T.M., he had been chairman of two of its important groups, D-5 on Coal and Coke, and D-3 on Gaseous Fuels, and he still directs the work of Committee D-5. Some of Dr. Fieldner's outstanding achievements were mentioned in the presentation including development of the standard for determining ash-softening temperature, studies of the gas- and coke-making properties of American coals, his studies of tunnel ventilation as well as his work in the testing of gas masks and gas adsorbents during World War I.

Catalogs and Literature Received

BURRELL TECHNICAL SUPPLY CO., 1936–42 Fifth Ave., Pittsburgh 19, Pa. A folder "Polishing Cloths and Abrasives for Metallurgical Laboratories" lists the various cloths numerically on the left page, while on the right, small samples of each cloth are arranged in the order of their quality. Under each sample is given the size and price of the cloth. Abrasive materials including description and price are listed on the lower left-hand page. Bulletin 202.

THE BALDWIN LOCOMOTIVE WORKS, Baldwin Southwark Division, Philadelphia, Pa. Bulletin 205, a four-page folder giving specifications and full details of the company's Sonntag Model SF-10R Rotating Beam Fatigue Testing Machine. The machine produces a constant bending moment from 0 to 10,000 inch-pounds on round specimens as large as one inch diameter. Illustrated.

EASTMAN KODAK CO., Rochester 4, N. Y. A new 44-page booklet describing photographic recording materials for use with cathode ray tube oscillographs, galvanometer oscillographs, and similar instruments. Entitled "Kodak Recording Materials," the booklet contains information on the physical and photographic properties of films and papers and on processing procedures, equipment, and materials. Equipment and technique for cathode ray tube photography are discussed and a table of relative speeds of films and papers is provided. A brief section is devoted to the use of conventional cameras and lens systems for photographing instrument dials, control boards, and similar devices. Write to Industrial Photographic Sales Division, Eastman Kodak Co., 343 State St., Rochester 4, N. Y.

NECROLOGY

(Dates of death are given where available)

A. O. BONIFACE, Trade Association Executive, New York, N. Y. (October 11, 1946). Member since 1944.

WILLIAM F. KELLERMANN, Senior Materials Engineer, Public Roads Administration, Federal Works Agency, Washington, D. C. (October 9, 1946). Member since 1938. Mr. Kellermann was active in A.S.T.M. committee work being a member of Committee C-9 on Concrete and Concrete Aggregates, where he served on the Advisory Committee, and Subcommittees VII and VIII on Methods and Apparatus for Testing Concrete and Admixtures, respectively, and he also served as chairman of Subcommittee XIII on Curing of Concrete. He represented Committee C-9 on the Section on Compression Testing of Committee E-1. Mr. Kellermann also was a member of Committee C-15 on Manufactured Masonry Units where he was chairman of Subcommittee V on Paving Brick.

FREDERIC KRAUTER SHIRK who was Research Engineer, Penn Worsted Co., Philadelphia, Pa., prior to serving in the war in Italy, was killed in action, February 14, 1945. He was a Major and was to be made Lieutenant Colonel the following month. Member since 1939.

C. F. W. RYS, Carnegie-Illinois Steel Corp., Pittsburgh, Pa. (October 11, 1946). Mr. RYS, a long-time member of the Society, first as an individual member and then as a representative of the membership held in the name of Carnegie Steel Co., later Carnegie-Illinois Steel Corp. Mr. Rys had been intensively interested in A.S.T.M. work from the date of his membership, 1909, and even earlier. He participated actively in the work of Committees A-1 on Steel and A-5 on Corrosion of Iron and Steel and was instrumental in having many of his associates participate in the Society's work. An outstanding authority in his field, he was made Chief Metallurgist of the combined Carnegie-Illinois Steel Corp., and later became Consulting Metallurgist. He had been in retirement for only about a year or so having purchased a farm at Christiana near Coatesville, when he suffered a stroke and a recurrence about two weeks later resulted in his death. In recognition of his work and interest in Committee A-1 on Steel, he had been elected an Honorary Member of this group.

J. EDGAR PEW, Vice-President, Sun Oil Co., Philadelphia, Pa. (October 22, 1946). Member since 1923. Mr. Pew, while not active in A.S.T.M. technical committee work, nevertheless exhibited genuine interest in many phases of the Society's activities, notably in the field of petroleum and materials and products going into the petroleum refining plant. He was a long-time officer and active member of the American Petroleum Institute, and just this year had completed 50 years of continuous service with his company.

Interesting Material in British Proceedings

THE recently published Proceedings of the British Institution of Mechanical Engineers, comprising Volume 152 for the calendar year 1945, have several groups of papers covering fields of work in which many A.S.T.M. members are active. There is a Symposium on Some Modern Aids in the Investigation of Materials, Mechanisms, and Structures, with other papers discussing Inspection Efficiency, The Application of Statistical Methods to the Control of Industrial Costs, and Sampling Schemes for Qualitative Inspection. Subjects covered in the Symposium include the following: Electrical Resistance Wire Strain Gages, Measurement of Displacement and Strain by Capacity Methods, The Measurement of Strain in Components of Complicated Form by Brittle Lacquer Coatings, High-Speed Cinematography, Temperature-indicating Paints and the Study of Internal Stress in a Metal by X-ray Diffraction.

There are a large number of other papers and reports in the I. Mech. E. Proceedings. Further information can be obtained by writing to the Institution, Storey's Gate, St. James's Park, London, S.W.1.

INDEX TO ADVERTISERS

PROFESSIONAL CARDS

On this page are announcements by leading organizations and individuals of their services for testing, research, and consulting work.

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Because of the unique combination of accuracy, speed and simplicity of operation which it affords, the Evelyn Colorimeter is used to equal advantage in both research and routine control laboratories. A detailed discussion of the design of this invaluable analytical tool is presented in our twelve-page Bulletin 460, available on request.

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Responsible in no small measure for the notable performance of the Evelyn Colorimeter is the Spotlight Galvanometer illustrated as a component of the instrument above. Equally applicable to many other physical and chemical measurements, this type of galvanometer is available in a complete series with sensitivities from 0.3 to 0.0006 microampere per mm. and with critical damping resistances from 12 to 50,000 ohms. These sturdy, multiple-reflection galvanometers are widely used in laboratory and in plant production work for both null and deflection measurements.

Fully Described in Bulletin 320

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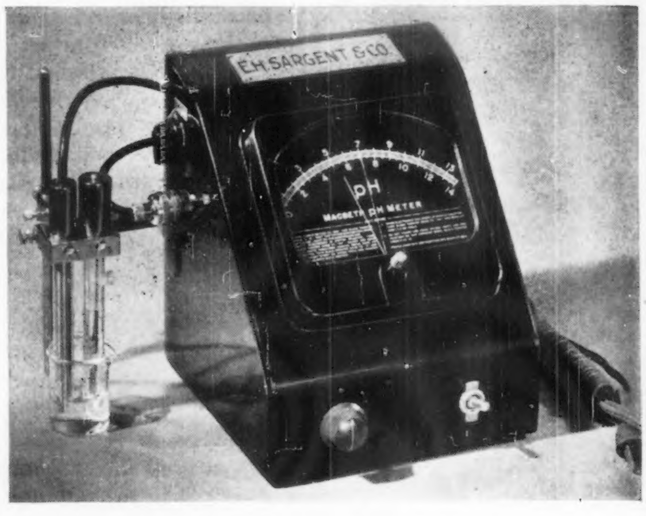

NO BATTERIES USED—The meter can be left on indefinitely for continuous pH indication—No worry about battery failure.
SIMPLIFIED OPERATION—Only one adjustment is necessary to operate the meter. Simple operating procedure is printed on the meter plate.
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NEW IMPROVED ELECTRODE ASSEMBLY—Designed to use the new Macbeth five-inch, shielded, high resistance, glass electrodes, or any standard electrodes of the same type. Electrodes may be replaced individually.
ELECTRODE SUPPORT—Horizontal metal bar attached to the meter case, provides adjustment for the electrode assembly at a suitable distance for acid-base titrations. A vertical rod permits adjustment of electrode height.
COMPACT UNIT—Sturdily constructed and housed in an aluminum case—dimensions are: width, 6¾ inches; depth, 6¾ inches; height, 8 inches. Meter mounting face at 45° angle to facilitate reading.

S-30231 pH METER—MACBETH, line operated, continuous indicating, glass electrode. Complete with new improved electrode assembly with 24″ terminal leads; integral electrode support and two standard buffer solutions pH 4 and pH 7. For operation from 115 volt, 50-60 cycle A.C. circuits. **$150.00**
S-30232—Ditto. But for operation from 230 volt 50-60 cycle A.C. circuits **$150.00**
S-30233 pH METER — MACBETH, Only. With integral electrode support but without electrode assembly. For operation from 115 volt 50-60 cycle A.C. circuits **$130.00**
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S-30237—ELECTRODE Only, glass **$9.00**
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S-30240—BUFFER SOLUTION—MACBETH pH 4 pH 7
Per 4 oz. bottle **$1.25** **$1.25**
S-30241—CARRYING CASE—LEATHER—For No. 30231 pH meter. This sturdy leather case accommodates the meter with electrodes and support; two buffer solutions and two Pyrex beakers, 50 ml capacity **$25.00**
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We wish to thank our many customers, whose continued use of "Precision Products" has made this fine new plant possible . . . over 130,000 sq. ft. devoted exclusively to the manufacture of Scientific Research and Production Control Equipment. We salute with deep pride and sincere admiration every laboratory man, from director to the newest technician; their untiring patience has given our country the greatest technological developments the world has ever seen. Again we say —
"THANK YOU" and "WELCOME TO OUR NEW HOME"
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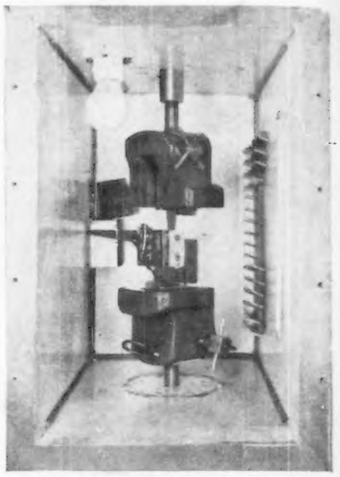
Scientific Research and Production Control Equipment

Sub-Zero Plastics tests at JOHNS HOPKINS University Research Laboratories *with* OLSEN PLASTIVERSAL



(A) Interior of low temperature cabinet showing sample racks and tension grips with extensometer attached.

The Laminated Plastics Test Project operated at Johns Hopkins University, in Baltimore, Maryland, has conducted over 5000 tension, compression, and flexure tests at temperatures ranging from — 100° F. to + 200° F. with the Olsen Plastiversal Testing Machine Illustrated here.

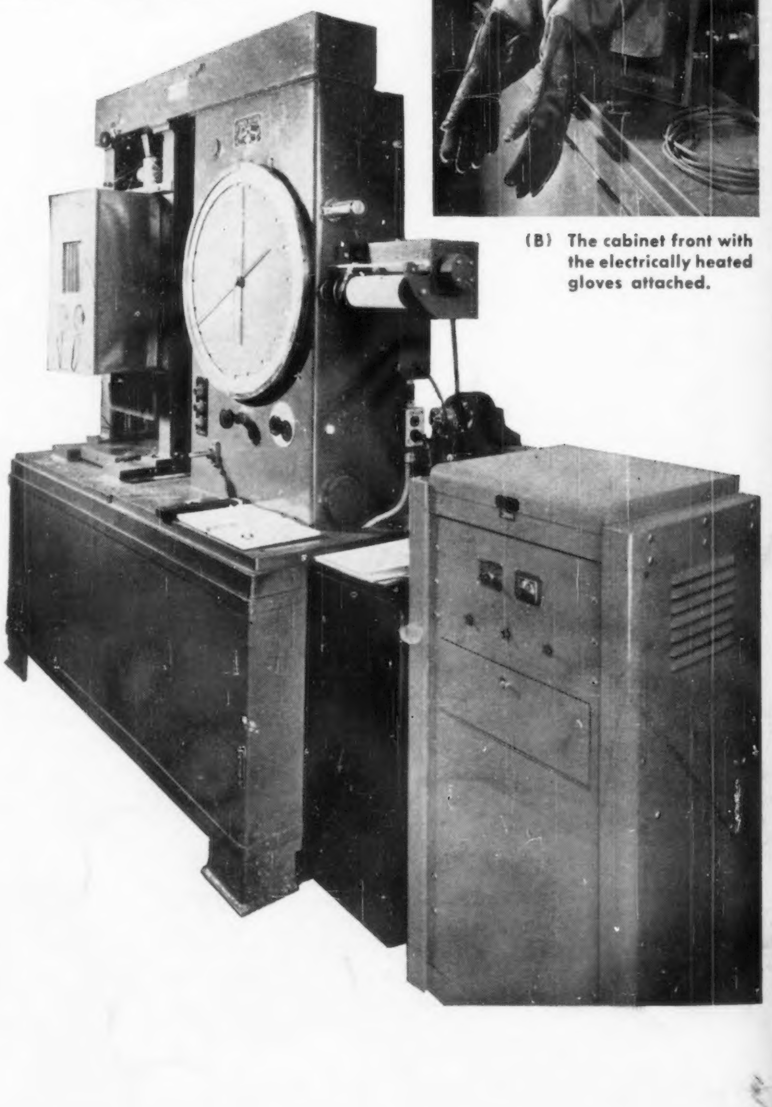
This project, sponsored by National Electrical Manufacturers Association, is under the direction of Dr. Ralph K. Witt, who devised the special low temperature testing techniques shown.

The Olsen Plastiversal Testing Machine is equipped with an Olsen Electronic High Magnification Recorder which produces, in chart form, an accurate stress-strain diagram of each test made. The specimen is placed in the tension, compression, or flexure clamps, with extensometer attached — all in the temperature controlled cabinet. The machine is put in operation and every step in the physical change of the specimen during the test is transmitted electronically to and recorded on a letter size chart for permanent record and subsequent study.

(B) The cabinet front with the electrically heated gloves attached.

The high accuracy, ease of operation, and dependability of this equipment is an invaluable aid in the comparison, standardization, control, and development of plastic materials.

The Olsen Plastiversal has been designed especially to meet the needs of the Plastics industry — it is but one of a number of perfected testing instruments for both laboratory and production use. We will be pleased to send complete details on Olsen Plastics Testing Equipment — Write today for Bulletin No. 23.



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